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Environmental Assessment of an Active Oil Field in the Northwestern Gulf of Mexico 1977-1978. Volume II. Data Management and Biological Investigations

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16. ABSTRACT

To obtain information concerning the environmental consequences of increased development of the outer continental shelf in the Gulf of Mexico, major research efforts are being made to document environmental conditions before, during, and after oil and gas production, and transmission. Among these efforts is the Environmental Assessment of the Buccaneer Oil and Gas Field. Objectives of the project are: (1) to identify and document the types and extent of biological, chemical and physical alterations of the marine ecosystem associated with Buccaneer Oil Field, (2) to determine specific pollutants, their quantity and effects, and (3) to develop the capability to describe and predict fate and effects of Buccaneer Oil Field contaminants. In 1977-78, investigations were intensified within Buccaneer Oil Field, comparing conditions around production platforms, which release various effluents including produced brine, with those around satellite structures (well jackets) which release no effluents. Volume 2 is concerned with data management and biological investigations. (Sinha - OEIS)

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VOLUME II - DATA MANAGEMENT AND BIOLOGICAL INVESTIGATIONS

A report to the Environmental Protection Agency on work conducted under provisions of Interagency Agreement EPA-IAG-D5-E693-EO During 1977-1978

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1979

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GUIDE TO USERS

This Annual Report is printed in three separate volumes:

Volume I - Synopsis

Volume II - Data Management and
Biological investigations

Volume III - Physical and Chemical Investigations

Volume I is designed to be used as a briefing document and as a key to more detailed scientific and technical information contained in Volumes II and III. Objectives, methods and results for each work unit are summarized in greatly abbreviated form within Volume I to facilitate dissemination of information. Thus, Volume I can be used alone or as a reference to companion Volumes II and III. Complete citations for literature cited in Volume I can be found in the Volumes II or III in which the detailed work unit reports are presented.

It is hoped that such an approach to environmental impact information dissemination will make the Annual Report a more useful and widely read document.

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FOREWORD

Increased development of the Federal outer continental shelf (OCS) in the Gulf of Mexico is expected as the U. S. attempts to reduce its dependency on foreign energy supplies. To obtain information concerning the environmental consequences of such development, the Federal Government is supporting major research efforts on the OCS to document environmental conditions before, during, and after oil and gas exploration, production, and transmission. Among these efforts is the Environmental Assessment of the Buccaneer Oil and Gas Field in the Northwestern Gulf of Mexico, a project funded by the Environmental Protection Agency (EPA) through interagency agreement with the National Oceanic and Atmospheric Administration (NOAA) and managed by the National Marine Fisheries Service (NMFS), Southeast Fisheries Center (SEFC), Galveston Laboratory in Galveston, Texas. Initiated in 1975, it was planned as a 5-year project which is now in its third year. Its major products are annual reports of findings, which are disseminated by the National Technical Information Service, data files disseminated by the Environmental Data and Information Service, and research papers written by participating investigators and published in scientific journals. Results are also made available through EPA/NOAA/NMFS project reviews, workshops and conferences attended by project participants, and various governmental, private, and public user groups.

Objectives of the project are (1) to identify and document the types and extent of biological, chemical and physical alterations of the marine ecosystem associated with Buccaneer Oil Field, (2) to determine specific pollutants, their quantity and effects, and (3) to develop the capability to describe and predict fate and effects of Buccaneer Oil Field contaminants. The project uses historical and new data and includes investigations both in the field and in the laboratory. A brief Pilot Study was conducted in the fall and winter of 1975-76, followed by an extensive survey in 1976-77 comparing the Buccaneer Oil Field area with adjacent undeveloped or control areas. In 1977-78, investigations were intensified within Buccaneer Oil Field, comparing conditions around production platforms, which release various effluents including produced brine, with those around satellite structures (well jackets) which release no effluents. Third-year studies around Buccaneer Oil Field structures are focusing on (1) determining concentrations and effects of pollutants in major components of the marine ecosystem, including seawater, surficial sediments, suspended particulate matter, fouling community, bacterial community, and fishes and macro-crustaceans, (2) effects of circulation dynamics and hydrography on distribution of pollutants, and (3) mathematical modeling to describe and predict sources, fate and effects of pollutants.

This project has provided a unique opportunity for continued study of effects of chronic, low-level contamination of the marine ecosystem associated with oil and gas production in an established field. In many respects, it represents a pioneering effort. It has been made possible through the cooperation of government agencies, Shell Oil Company (which owns and operates the field) and various contractors including universities and private companies. It is anticipated that the results of this project will impact in a significant way on future decisions regarding operations of oil and gas fields on the OCS.

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Evelyn S. Chang, M. S. Thesis, University of Houston, 1978. Sterols in the Marine Food Web.

INTRODUCTION

Location of Study Area

The area selected for study is the operational Buccaneer Oil Field located approximately 49.6 kilometers (26.8) nautical miles), from the Galveston Sea Buoy south southeast to production platform 296-B off Galveston, Texas (Figure 1). This field was selected as the study area because: (a) the field had been in production for about 15 years, which time had allowed full development of the oil-field-associated marine communties; (b) it was isolated from other fields which facilitated the selection of an unaltered area (for comparison) within a reasonable distance of the field; (c) it produced both oil and gas that represented a major portion of the pollutants from marine mineral extraction; (d) its location simplified logistics and reduced the cost of the research; and (e) the Texas offshore area had not been fully developed for gas and oil production but was expected to experience accelerated exploitation in the future.

Oil Field Operation History

The Buccaneer Oil Field was developed by the Shell Oil Company in four blocks of land that were leased in 1960 and 1968 as follows:

Year	Lease Number	Block Number	Acreage	Hectares
1960	G0709	288	2,790	1,129
1960	G0713	295	4,770	1,930
1960	G0714	296	4,501	1,821
1968	G1783	289	2,610	1,056

In the development of the field, 17 structures have been built; two are production platforms, two are quarters platforms, and 13 are satellite structures surrounding well jackets. Initial exploratory drilling began about mid-summer of 1960 with mobile drilling rigs. When (as the result of the exploratory drilling) the proper locations for platforms were selected, permanent platforms were constructed.

There has been no reported history of major oil spills from this field. Although there undoubtedly have been losses of from a barrel of oil upward because of the mechanical failure of various pieces of equipment, there have been no major oil spills, the largest spill being three barrels in 1973. The reported oil spill chronology and quantity for Buccaneer Field was as follows:

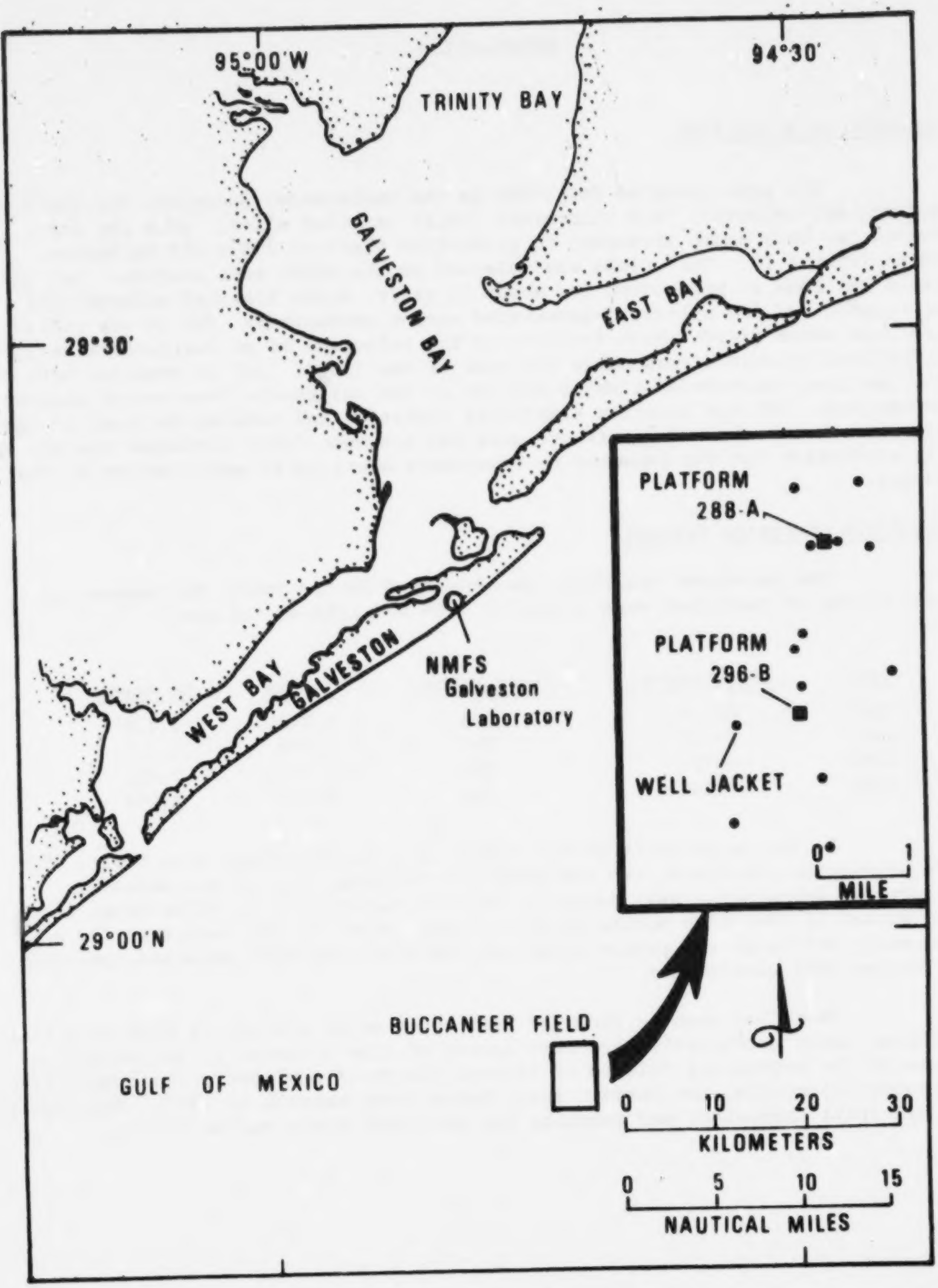
95°00'W
94°30'
TRINITY BAY
GALVESTON BAY
EAST BAY
28°30'
29°00'N
WEST BAY
GALVESTON
NMFS
Galveston
Laboratory
PLATFORM
288-A
PLATFORM
296-B
WELL JACKET
0
1
MILE
BUCCANEER FIELD
GULF OF MEXICO
0
10
20
30
KILOMETERS
0
5
10
15
NAUTICAL MILES

FIGURE 1. LOCATION OF BUCCANEER OIL FIELD

Date	Source	Amount Barrels	 Liters
September 1973	Platform 296-B	0.5	79
November 1973	Unknown	3.0	477
July 1974	Platform 296-B	0.5	79
August 1974	Platform 296-B	1.7	265
September 1975	Platform 288-A	0.2-0.4	38-56
Totals		5.9-6.1	938-956

The Buccaneer Oil Field first began operations with the production of oil. Later, when significant quantities of gas were found, the field began producing both oil and gas and has continued to do so to date.

The production platforms and satellites (well jackets) are connected by a number of pipelines with a 20-inch diameter main pipeline connecting the field to shore. All of the pipelines that are 10 inches or greater in diameter are buried. The Blue Dolphin Pipeline Company was granted a pipeline permit (No. G1381, Blocks 288 and 296) in 1965 and has operated the pipeline since its construction.

The Buccaneer Oil Field occupies a limited area (about 59.3 km^2; 22.9 sq. statute miles) leased in the northwestern Gulf of Mexico. Because of the geographically small size of this area and because major environmental similarities occur over much of the western Gulf of Mexico, it is anticipated that the results of the proposed studies can be extrapolated, to some extent, to other areas off the Texas coast where oil fields occur or will be developed in the foreseeable future.

Four types of structures located in Buccaneer Oil Field (production platform, quarters platform, satellite (well) jacket, and flare stack), to be referred to in this report, are shown in Figure 2, which is an oblique aerial photograph of production platform 288-A and vicinity within Buccaneer Oil Field. A map of Buccaneer Oil Field, (Figure 3) depicts the locations of platforms and satellite jackets within the field. Table 1 is a key to designations used by each work unit and by Shell Oil Company for these locations.

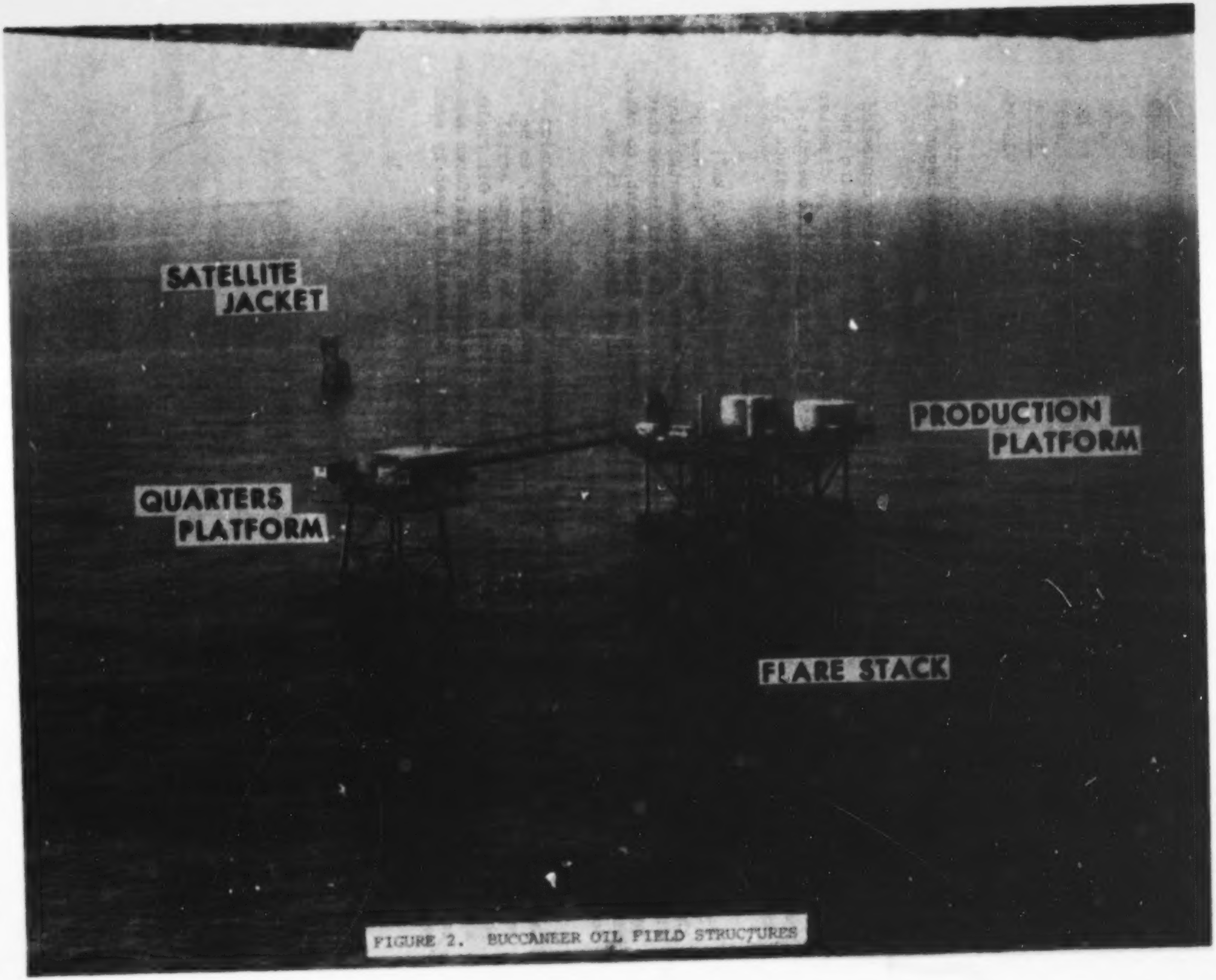
SATELLITE JACKET
QUARTERS PLATFORM
PRODUCTION PLATFORM
FLARE STACK

FIGURE 2. BUCCANEER OIL FIELD STRUCTURES

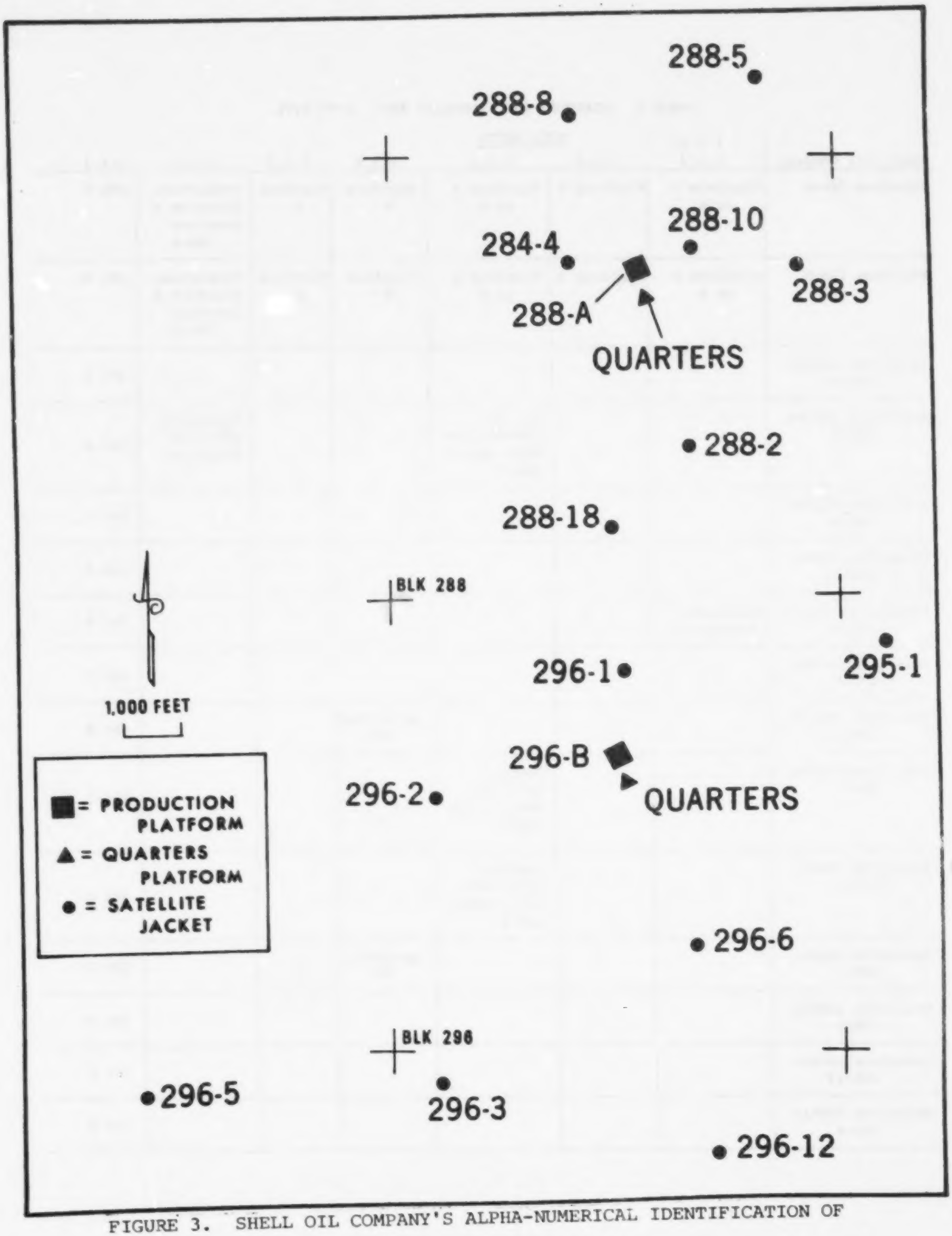
288-5
288-8
288-10
284-4
288-3
288-A
QUARTERS
288-2
288-18
BLK 288
295-1
296-1
1,000 FEET
296-B
QUARTERS
296-2
■ = PRODUCTION PLATFORM
▲ = QUARTERS PLATFORM
● = SATELLITE JACKET
296-6
BLK 296
296-5
296-3
296-12

FIGURE 3. SHELL OIL COMPANY'S ALPHA-NUMERICAL IDENTIFICATION OF BUCCANEER OIL FIELD STRUCTURES

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	WORK UNITS						
Shell Oil Company	2.3.2/ 2.4.2	2.3.4	2.3.5	2.3.6	2.3.7	2.3.8	2.4.1
Platform 288-A	Platform A or A	Platform A	Platform A or A	Platform "A"	Platform A	Production Platform & Quarters 288-A	pfm A
Platform 296-B	Platform B or B	Platform B	Platform B or B	Platform "B"	Platform B	Production Platform & Quarters 296-B	pfm B
Satellite Jacket 288-8							jkt A
Satellite Jacket 288-5			Control 288-5, C or Well Jacket 288-5			Satellite 288-5 or Satellite	jkt B
Satellite Jacket 288-4							jkt C
Satellite Jacket 288-10							jkt E
Satellite Jacket 288-3	Satellite Structure S						jkt F
Satellite Jacket 288-2							jkt G
Satellite Jacket 288-19				Satellite "H"			jkt H
Satellite Jacket 296-1			Control 296-1 or Well Jacket 296-1				jkt I
Satellite Jacket 295-1			Control 295-1 or Well Jacket 295-1				jkt J
Satellite Jacket 296-2				Satellite "S"			jkt K
Satellite Jacket 296-3							jkt M
Satellite Jacket 296-12							jkt N
Satellite Jacket 296-6							jkt O

Work Unit 2.2.3 Buccaneer Oil Field Study
Data Management and System Development
Final Report

NMFS/SEFC National Space Technology Laboratories

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ABSTRACT

The goal of the Buccaneer Oil Field Project is to establish and evaluate the effects of active oil fields on marine ecosystems in the northwestern Gulf of Mexico. To make readily available the large amount of of data gathered and analyzed, an effective data management system was created with the objectives of ensuring an integrated master project data set and providing a smooth flow of data products from field collectors to analysis and to ultimate users.

Data management activities of the project include:

1. Creation and maintenance of a master data file for all project data.
2. Technical support for developing formats and log forms.
3. Technical support to provide keypunch and verification of project data.
4. Technical support to process data and to provide data verfication reports to insure data quality and quantity.
5. Maintenance of data transaction and control logs.
6. Provide processed data to NOAA's Environmental Data and Information Services (EDIS) for archival in the specified format.

Presently, data input formats for every element of the project have been designed, developed and utilized. A control function for handling data transaction and control logs has been implemented and utilized throughout the project. A system for creation and maintenance of a master data file has been implemented on the UNIVAC 1108 at the Slidell Computer Complex, Slidell, La. Seven of the ten task data files are complete and contain approximately 220,000 characters of information. The remaining data should be acquired by August 31, 1978, and the master file will be completed. Development of archival data formats

and preparation of archival tapes will be completed with delivery of data to EDIS in the next two months as scheduled.

In addition, technical interface and coordination with Principal Investigators, EDIS, and the project office continues to be provided with respect to all project data management activities.

All data acquired during the 1976-1977 project year and most of the data acquired during the 1977-1978 project is presently being stored at the Slidell Computer Complex and is available to project users. In addition, all data acquired during the 1976-1977 project year is being stored by Environmental Data and Information Service and is available to non-project users. The data acquired during the 1977-1978 project year should be available to non-project users by October 31, 1978.

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1	Data Management Overview	2.2.3-2
2	Buccaneer Oil Field Study Data Flow (1977-78)	2.2.3-3
3	NFEL Control/Log Form	2.2.3-6
4	Univac 1108 Multiprocessor (1108-01)	2.2.3-13

BUCCANEER OIL FIELD STUDY DATA MANAGEMENT AND SYSTEM DEVELOPMENT FINAL REPORT

INTRODUCTION

The objective of this report is to outline the basic data management plan and to provide the present status of all data management activities.

The goal of the Buccaneer Oil Field Project is to establish and evaluate the effects of active oil fields on marine ecosystems in the northwest Gulf of Mexico. The design of the project is to compare environmental conditions in an established oil and gas field with those in a similar but unaltered area. The objectives are twofold: (1) describe the existing ecosystems and variabilities in components for an active oil field and an unaltered area, and (2) compare the concentrations of pollutants in the water, sediments, and biota, found in an active oil field with those of an unaltered area and identify those changes associated with oil exploration and production. In order that the large amount of data gathered and analyzed be made readily available, an effective data management system has been created to provide a smooth flow of data products from the field collectors to the analysts to the ultimate users. A data management overview is given in Figure 1.

DATA FLOW

Data will flow from the field samplers to the Principal Investigators to the Data Manager to the archival center. Principal Investigators will obtain data from the Data Manager after a master data file has been established. A graphic representation of data flow for the 1977-1978 study period is given in Figure 2. Non-project data users nor-

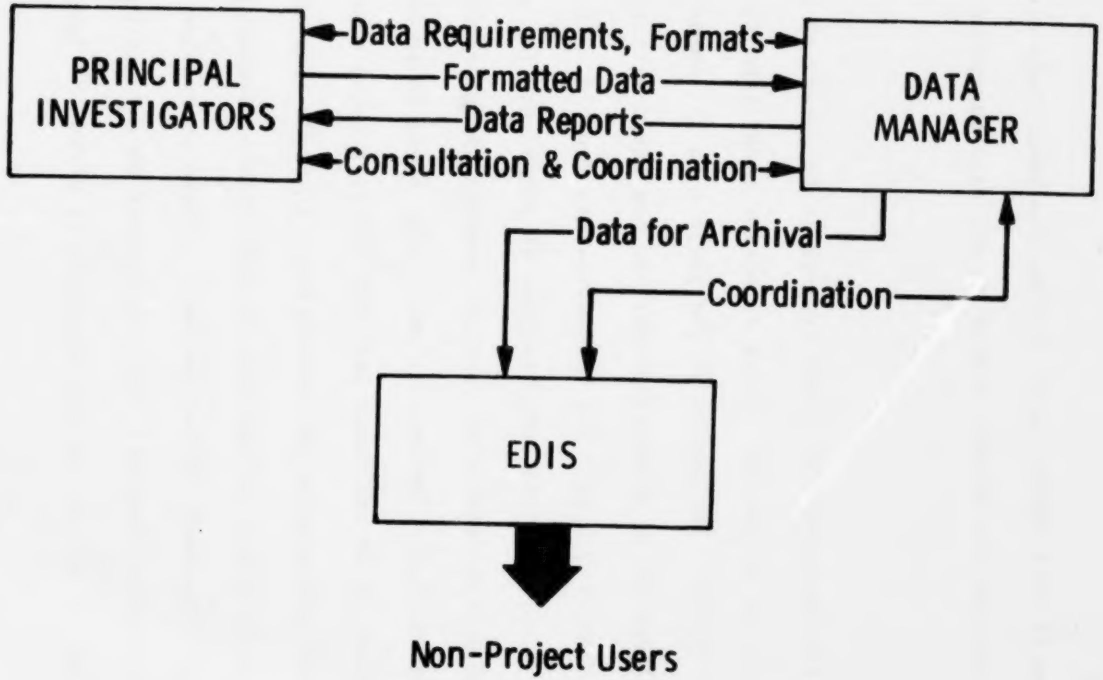

PRINCIPAL INVESTIGATORS
Data Requirements, Formats
Formatted Data
Data Reports
Consultation & Coordination
DATA MANAGER
Data for Archival
Coordination
EDIS
Non-Project Users

Figure 1. Data Management Overview

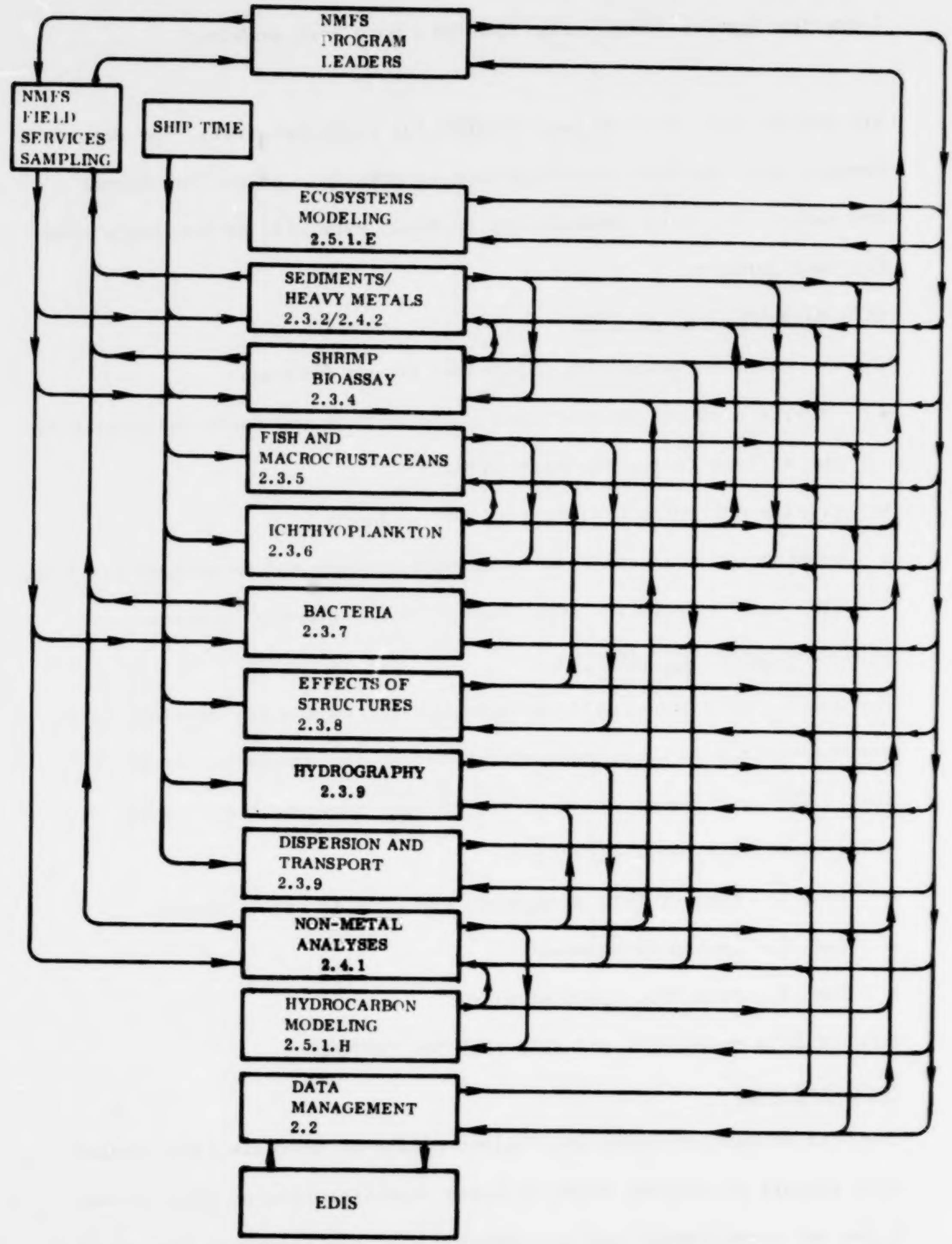

NMFS PROGRAM LEADERS
NMFS FIELD SERVICES SAMPLING
SHIP TIME
ECOSYSTEMS MODELING 2.5.1.E
SEDIMENTS/ HEAVY METALS 2.3.2/2.4.2
SHRIMP BIOASSAY 2.3.4
FISH AND MACROCRUSTACEANS 2.3.5
ICHTHYOPLANKTON 2.3.6
BACTERIA 2.3.7
EFFECTS OF STRUCTURES 2.3.8
HYDROGRAPHY 2.3.9
DISPERSION AND TRANSPORT 2.3.9
NON-METAL ANALYSES 2.4.1
HYDROCARBON MODELING 2.5.1.H
DATA MANAGEMENT 2.2
EDIS

Figure 2. Buccaneer Oil Field Study Data Flow (1977-78)

mally will have to obtain data from the Environmental Data and Information Service (EDIS) after the data have been archived.

All project data will be sent to EDIS for final archival. The Data Manager will transmit processed data to EDIS in a prescribed format and media. Prior to transmission to EDIS, data will be available from the Data Manager.

DATA MANAGEMENT OBJECTIVES

The overall data management objectives are as follows:

- Provide a smooth flow of data products from the field collectors to the analyst to the ultimate users.
- Provide EDIS with project data for archival.
- Develop and evaluate data management systems and techniques for handling multi-discipline input data from experimental sources.

DATA MANAGEMENT REQUIREMENTS

The overall data management requirements are to design, develop, test, and operate a data management system for the Buccaneer Oil Field Project. The development of an efficient data management system was divided into three basic work tasks:

- Task 1 - Project Data Management and EDIS Archival Support
- Task 2 - System Development
- Task 3 - Data Base Administration

PROJECT DATA MANAGEMENT AND EDIS ARCHIVAL SUPPORT

Task Workscope

The Data Manager provides the Project Office an umbrella data management support capability which includes identification of data deliverables and requirements and coordination with the Principal Investigators to identify formats compatible with the EDIS data archival requirements.

This support includes temporary storage of project data and actual submittal of data to EDIS in their prescribed format.

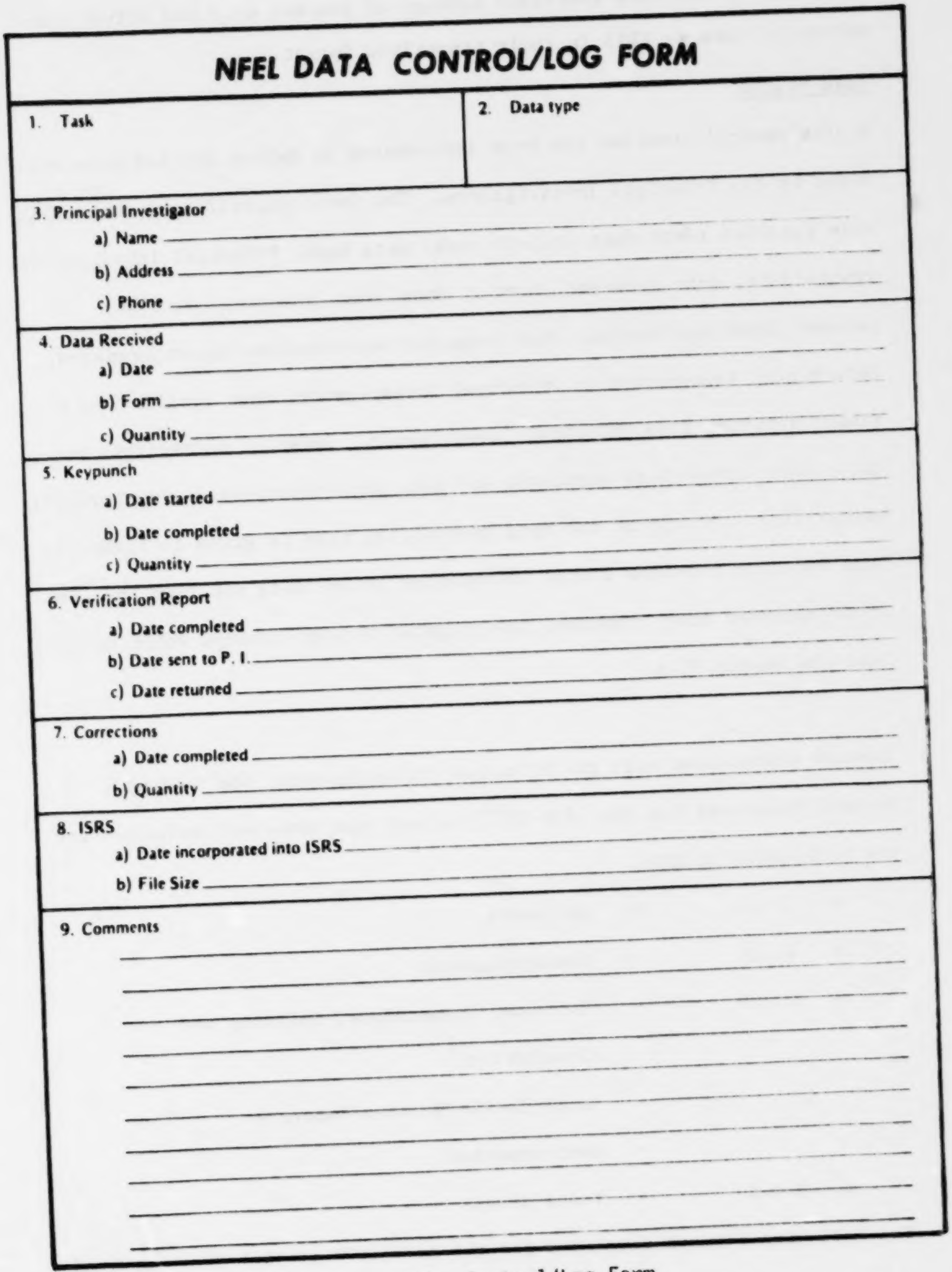
Task Status

A data control function has been implemented to manage project data provided by the Principal Investigators. The data control/log form used in this function identifies project task, data type, Principal Investigator, cruise/date, date received, form of data, data quantity, date keypunched (when applicable), date computer verification report prepared, date report transmitted to Principal Investigator, date verified data report returned from Principal Investigator, number of corrections to data, date corrections completed and date data incorporated into project master file. A copy of the data control/log form is given in Figure 3. This function provides status information on any data set from the time if is received from Principal Investigator through incorporation of data into the master file.

Through discussions with the Principal Investigators, the following formats developed for the 1976-1977 project year remained unchanged and are acceptable to EDIS.

- 2.3.2 - Sediments
- 2.3.6 - Ichthyoplankton
- 2.3.9 - Currents, Temperature, Salinity and Circulation
  - Drift Bottle Release/Recovery
  - Environmental
- 2.4.2 - Trace Metals

The following formats developed for the 1976-1977 project year required minor modifications:



NFEL DATA CONTROL/LOG FORM

1. Task
2. Data type
3. Principal Investigator
   a) Name
   b) Address
   c) Phone
4. Data Received
   a) Date
   b) Form
   c) Quantity
5. Keypunch
   a) Date started
   b) Date completed
   c) Quantity
6. Verification Report
   a) Date completed
   b) Date sent to P. I.
   c) Date returned
7. Corrections
   a) Date completed
   b) Quantity
8. ISRS
   a) Date incorporated into ISRS
   b) File Size
9. Comments

NFEL 100

Figure 3. NFEL Control/Log Form

- 2.3.5 - Fish and Macrocrustaceans
    - Demersal Fish
    - Reef Fish
- 2.4.1. - Non-Metal Analysis

The following archival data formats were developed and sent to EDIS for approval:

- 2.3.4 - Shrimp Bioassay
- 2.3.5 - Fish and Macrocrustaceans
    - Reef Fish Census
    - Demersal Fish Census
    - Fish Bioassay
    - Brine Dye Release
    - Stomach Contents
- 2.3.7 - Bacteria
    - Behavior
    - Enumeration
    - Degradation Rates
    - Taxonomy
- 2.3.8 - Effects of Structures
    - Fish Tagging
    - Fish Recapture
    - Food Habits
    - Stomach Contents
    - Biofouling
    - Respirometry Experiment
- 2.3.9 - Currents, Temperature, Salinity and Circulation
    - Dye Study

- Transponding Buoys

Data from all 1977-1978 project tasks have been received. The program task, data type and file size for each data source received from the Principal Investigators are as follows:

TASKS	DATA TYPE	FILE SIZE IN CHARACTERS
2.3.2	Sediments	1,500
2.3.4	Shrimp Bioassay	12,200
2.3.5	Fish and Macrocrustaceans	
	- Demersal Fish	16,000
	- Reef Fish	1,000
	- Fish Bioassay	2,200
	- Brine Dye Release	400
	- Stomach Contents	20,000
	- Pelagic Fish Census	20,500
	- Reef Fish Census	3,700
2.3.6	Ichthyoplankton	48,000
2.3.7	Bacteria	
	- Behavior	2,900
	- Enumeration	4,400
	- Degradation Rates	3,100
	- Taxonomy	11,500
2.3.8	Effects of Structures	
	- Fish Tagging	1,900
	- Fish Recapture	200
	- Food Habits	300
	- Stomach Contents	1,200
	- Biofouling	11,500

2.3.8	(cont'd) - Respirometry Experiment	-
2.3.9	Currents, Temperature, Salinity and Circulation	
	- Drift Bottle Release/Recovery	1,300
	- Environmental	1,600
	- Dye Study	900
	- Transponding Buoys	4,300
	- Currents and Circulation	250,000
2.4.1	Non-Metal Analysis	100,000
2.4.2	Trace Metals	4,500

All data received in the 1976-1977 project year, along with the data documentation forms, have been sent to EDIS. A copy of the EDIS data documentation form is given in Appendix 1.

A copy of all data documentation forms for the 1976-1977 project year is being maintained at the Slidell Computer Complex and Xerox copies are available upon request.

SYSTEM DEVELOPMENT

Task Workscope

The functions of the Data Manager in this task are as follows:

- Identify all input data types and formats through discussions with the Principal Investigators
- Design and develop data verification report software for all data types
- Design and develop a software system to query the master data file.

Task Status

All Principal Investigators have been contacted to identify input data types and develop mutually acceptable data acquisition formats. The following data acquisition formats from the 1976-1977 project year remain unchanged and have been utilized for the 1977-1978 project year:

- 2.3.2 - Sediments
- 2.3.6 - Ichthyoplankton
- 2.3.9 - Currents, Temperature, Salinity and Circulation
  - Drift Bottle Release/Recovery
  - Environmental
- 2.4.2 - Trace Metals

The following data acquisition formats from the 1976-1977 project year required minor modifications before utilization for the 1977-1978 project year:

- 2.3.5 - Fish and Macrocrustaceans
  - Demersal Fish
  - Reef Fish
- 2.4.1 - Non-Metal Analysis

During the 1977-1978 project year, new tasks (2.3.4 - Shrimp Bioassay and 2.3.7 - Bacteria) were added, existing tasks (2.3.5 - Fish and Macrocrustaceans and 2.3.9 - Currents, Temperature, Salinity and Circulation) were expanded and an existing task (2.3.8 - Effects of Structures) was redefined. After review of existing data acquisition formats, the Principal Investigators associated with these tasks were contacted to identify input data types and develop mutually acceptable data acquisition formats. Information acquired dictated the design/development of new data acquisition forms for the following tasks/data types.

- 2.3.4 - Shrimp Bioassay
- 2.3.5 - Fish and Macrocrustaceans
    - Reef Fish Census
    - Demersal Fish Census
    - Brine Dye Release
    - Stomach Contents
    - Fish Bioassay
- 2.3.7 - Bacteria
    - Enumeration
    - Taxonomy
    - Degradation Rates
    - Behavior
- 2.3.8 - Effects of Structures
    - Fish Tagging
    - Fish Recapture
    - Food Habits
    - Biofouling
    - Respirometry Experiment
    - Stomach Contents
- 2.3.9 - Currents, Temperature, Salinity and Circulation
    - Dye Study

2.3.9 (cont'd) - Transponding Buoys

- Currents

Data acquisition forms and instruction sheets have been printed and distributed to all Principal Investigators of all tasks. The data acquisition forms and instruction sheets for all tasks are given in Appendix 2.

In order to insure data quality and quantity, software was designed/developed for all data types to produce data verification reports. These reports have been to the respective Principal Investigators for their review and to correct all errors (where necessary). An example of each data verification report is given in Appendix 3.

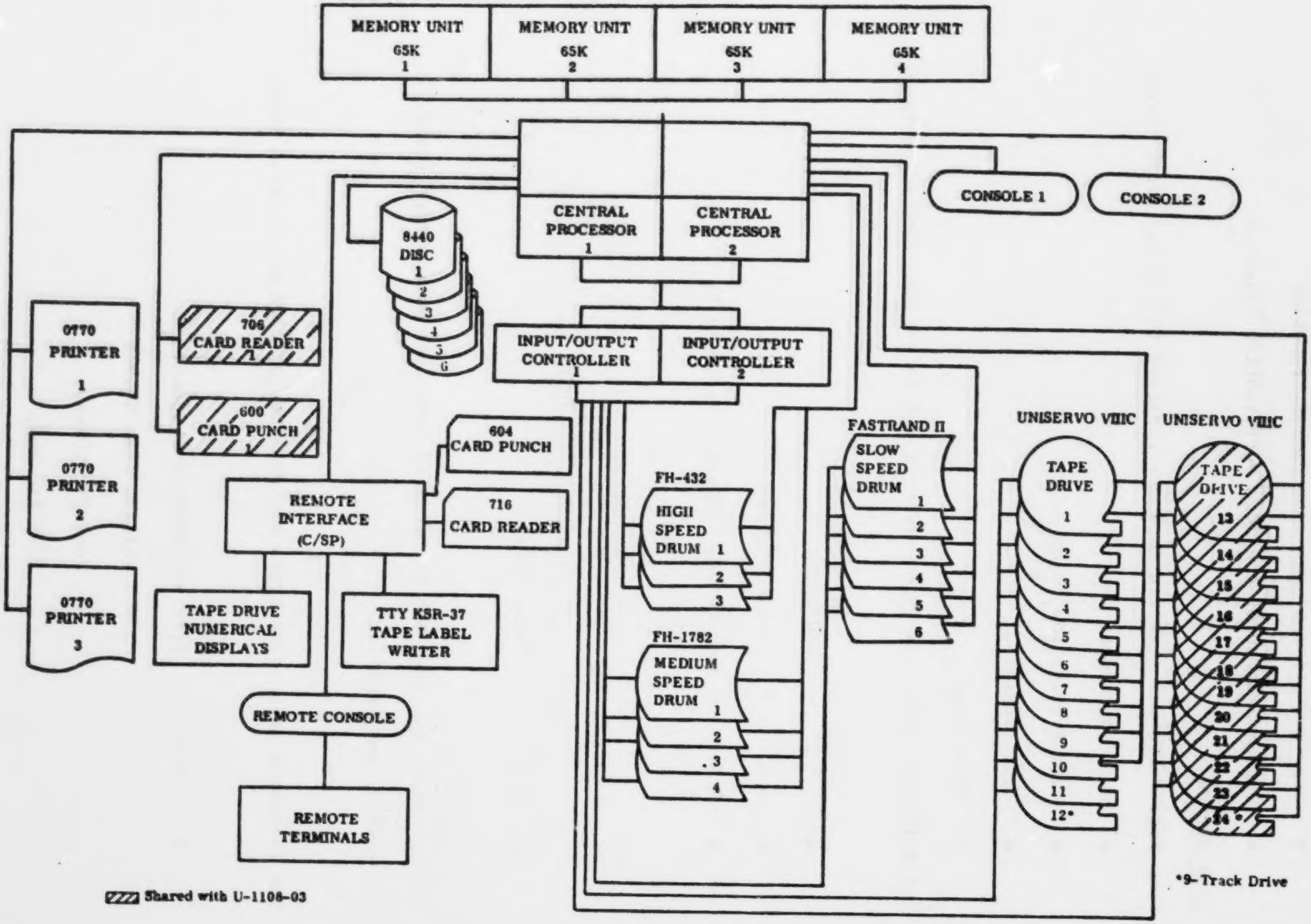
All software to be utilized has been written in FORTRAN V and implemented on the UNIVAC 1108 at the Slidell Computer Center. System configuration for the UNIVAC 1108 system being utilized is given in Figure 4.

DATA BASE ADMINISTRATION

Task Workscope

The primary objective of the Data Base Administration Task is to ensure a fully operational data management system for effective and efficient user access. System changes have been made in response to changing Project requirements and user needs. In particular, the 1976-1977 system has been changed to provide more emphasis on the acquisition, verification and archival of the data. The Data Manager provides the following services:

- Manage the data base for support of project users.


MEMORY UNIT 65K 1
MEMORY UNIT 65K 2
MEMORY UNIT 65K 3
MEMORY UNIT 65K 4
CENTRAL PROCESSOR 1
CENTRAL PROCESSOR 2
CONSOLE 1
CONSOLE 2
INPUT/OUTPUT CONTROLLER 1
INPUT/OUTPUT CONTROLLER 2
8440 DISC 1 2 3 4 5 6
0770 PRINTER 1
0770 PRINTER 2
0770 PRINTER 3
706 CARD READER
600 CARD PUNCH
604 CARD PUNCH
716 CARD READER
REMOTE INTERFACE (C/SP)
TAPE DRIVE NUMERICAL DISPLAYS
TTY KSR-37 TAPE LABEL WRITER
REMOTE CONSOLE
REMOTE TERMINALS
FH-432 HIGH SPEED DRUM 1 2 3
FH-1782 MEDIUM SPEED DRUM 1 2 3 4
FASTRAND II SLOW SPEED DRUM 1 2 3 4 5 6
UNISERVO VIIIC TAPE DRIVE 1 2 3 4 5 6 7 8 9 10 11 12*
UNISERVO VIIIC TAPE DRIVE 13 14 15 16 17 18 19 20 21 22 23 24*

▨ Shared with U-1108-03

*9-Track Drive

Figure 4. UNIVAC 1108 Multiprocessor (1108-01)

- Maintain data base configuration and integrity
- Inplementation of the data control function
- Implementation of the data verification function

Task Status

Data from Principal Investigators are received in the following forms:

- Data worksheets
- Data Acquisition forms
- Data cards
- Data Tapes

The following data task/types are received in the data worksheet form.

- 2.3.2 - Sediments
- 2.3.4 - Shrimp Bioassay
- 2.3.9 - Currents, Temperature, Salinity and Circulation
    - Dye Study
    - Transponding Buoy
- 2.4.2 - Trace Metals

Upon receipt, the data are transcribed onto data acquisition forms, keypunched, and verified.

The following data tasks/types are received on data acquisition forms:

- 2.3.5 - Fish and Macrocrustaceans
    - Pelagic Fish Census
    - Reef Fish Census
    - Fish Bioassay

2.3.5 (cont'd)
  - Brine Dye Release
  - Stomach Contents
  - Reef Fish
  - Demersal Fish

- 2.3.7 - Bacteria
  - Behavior
  - Enumeration
  - Taxonomy
  - Degradation Rates
- 2.3.8 - Effects of Structures
  - Fish Tagging
  - Fish Recapture
  - Food Habits
  - Stomach Contents
  - Biofouling
  - Respirometry Experiment
- 2.3.9 - Currents, Temperature, Salinity and Circulation
  - Drift Bottle Release/Recovery
  - Environmental
- 2.4.1 - Non-Metal Analysis

Data received in this form are keypunched and verified.

The data from task 2.3.6 - Ichthyoplankton are received in data card form.

The data from task 2.3.9 - Currents, Temperature, Salinity and Circulation - Current data will be written on a 7-track BCD tape.

Data verification reports for all data types are generated and sent to the Principal Investigators for review and corrections. The following data types have been verified:

- 2.3.2 - Sediments
- 2.3.5 - Fish and Macrocrustaceans
    - Pelagic Fish Census
    - Reef Fish Census
    - Fish Bioassay
    - Brine Dye Release
    - Reef Fish
    - Demersal Fish
    - Stomach Contents
- 2.3.6 - Ichthyoplankton
- 2.3.8 - Effects of Structures
    - Fish Tagging
    - Fish Recapture
    - Food Habits
- 2.3.9 - Currents, Temperature, Salinity and Circulation
    - Environmental
    - Drift Bottle Release/Recovery
    - Transponding Buoy
    - Dye Study
- 2.4.2 - Trace Metals

A copy of all verified data from Task 2.3.5 - Fish and Macrocrustaceans in punched card form for the 1976-1977 and 1977-1978 project years was provided to LGL in response to a project office approved request.

Copies of all 1976-1977 data from the following tasks were provided to the Project Office.

- 2.3.2 - Sediments
- 2.4.1 - Hydrocarbons
- 2.4.2 - Trace Metals

APPENDIX 1

DATA DOCUMENTATION FORM

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best available copy.

ACCESSION NUMBER

DATA DOCUMENTATION FORM

NOAA FORM 24-13
(4-77)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEANOGRAPHIC DATA CENTER
RECORDS SECTION
WASHINGTON, DC 20235

FORM APPROVED
O.M.B. No. 41-R2651
EXPIRES 1-81

(While you are not required to use this form, it is the most desirable mechanism for providing the required ancillary information enabling the NODC and users to obtain the greatest benefit from your data.)

This form should accompany all data submissions to NODC. Section A, Originator Identification, must be completed when the data are submitted. It is highly desirable for NODC to also receive the remaining pertinent information at that time. This may be most easily accomplished by attaching reports, publications, or manuscripts which are readily available describing data collection, analysis, and format specifics. Readable, handwritten submissions are acceptable in all cases. All data shipments should be sent to the above address.

A. ORIGINATOR IDENTIFICATION

THIS SECTION MUST BE COMPLETED BY DONOR FOR ALL DATA TRANSMITTALS

1. NAME AND ADDRESS OF INSTITUTION, LABORATORY, OR ACTIVITY WITH WHICH SUBMITTED DATA ARE ASSOCIATED

2. EXPEDITION, PROJECT, OR PROGRAM DURING WHICH DATA WERE COLLECTED

3. CRUISE NUMBER(S) USED BY ORIGINATOR TO IDENTIFY DATA IN THIS SHIPMENT

4. PLATFORM NAME(S)	5. PLATFORM TYPE(S) *(E.G., SHIP, BUOY, ETC.)*	6. PLATFORM AND OPERATOR NATIONALITY(IES)		7. DATES	
		PLATFORM	OPERATOR	FROM: MO/DAY/YR	TO: MO/DAY/YR

8. ARE DATA PROPRIETARY?

☐ NO ☐ YES

IF YES, WHEN CAN THEY BE RELEASED FOR GENERAL USE? YEAR ____ MONTH ____

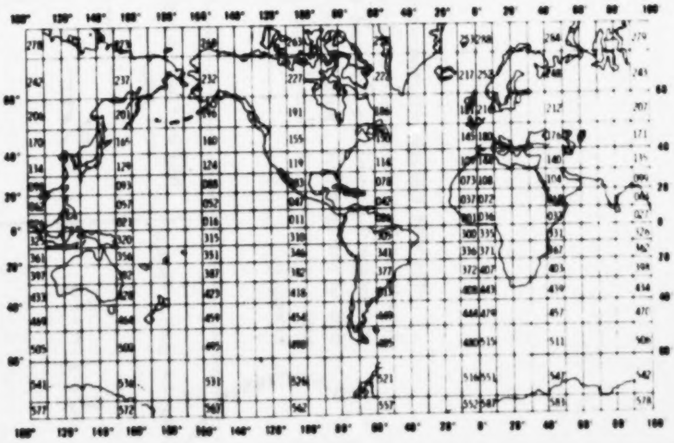
9. ARE DATA DECLARED NATIONAL PROGRAM (DNP)? (I.E., SHOULD THEY BE INCLUDED IN WORLD DATA CENTERS HOLDINGS FOR INTERNATIONAL EXCHANGE?)

☐ NO ☐ YES ☐ PART *(SPECIFY BELOW)*

10. PERSON TO WHOM INQUIRIES CONCERNING DATA SHOULD BE ADDRESSED WITH TELEPHONE NUMBER *(AND ADDRESS IF OTHER THAN IN ITEM-1)*

11. PLEASE DARKEN ALL MARSDEN SQUARES IN WHICH ANY DATA CONTAINED IN YOUR SUBMISSION WERE COLLECTED.

GENERAL AREA



NOAA FORM 24-13

B. SCIENTIFIC CONTENT

Include enough information concerning manner of observation, instrumentation, analysis, and data reduction routines to make them understandable to future users. Furnish the minimum documentation considered relevant to each data type. Documentation will be retained as a permanent part of the data and will be available to future users. Equivalent information already available may be substituted for this section of the form (i.e., publications, reports, and manuscripts describing observational and analytical methods). If you do not provide equivalent information by attachment, please complete the scientific content section in a manner similar to the one shown in the following example.

EXAMPLE (HYPOTHETICAL INFORMATION)

NAME OF DATA FIELD	REPORTING UNITS OR CODE	METHODS OF OBSERVATION AND INSTRUMENTS USED (SPECIFY TYPE AND MODEL)	ANALYTICAL METHODS (INCLUDING MODIFICATIONS) AND LABORATORY PROCEDURES	DATA PROCESSING TECHNIQUES WITH FILTERING AND AVERAGING
Salinity	‰	Nansen bottles	Inductive salinometer (Hytech model S510)	N/A (Not applicable)
		STD Bissett-Berman Model 9006	N/A	Values averaged over 5-meter intervals
Water color	Forel scale	Visual comparison with Forel bottles	N/A	N/A
Sediment size	ϕ units and percent by weight	Ewing corer	Standard sieves Carbonate fraction removed by acid treatment	Same as "Sedimentary Rock Manual," Folk '65

(SPACE IS PROVIDED ON THE FOLLOWING TWO PAGES FOR THIS INFORMATION)

B. SCIENTIFIC CONTENT

NAME OF DATA FIELD	REPORTING UNITS OR CODE	METHODS OF OBSERVATION AND INSTRUMENTS USED (SPECIFY TYPE AND MODEL)	ANALYTICAL METHODS (INCLUDING MODIFICATIONS) AND LABORATORY PROCEDURES	DATA PROCESSING TECHNIQUES WITH FILTERING AND AVERAGING

NOAA FORM 24-13

B. SCIENTIFIC CONTENT

NAME OF DATA FIELD	REPORTING UNITS OR CODE	METHODS OF OBSERVATION AND INSTRUMENTS USED (SPECIFY TYPE AND MODEL)	ANALYTICAL METHODS (INCLUDING MODIFICATIONS) AND LABORATORY PROCEDURES	DATA PROCESSING TECHNIQUES WITH FILTERING AND AVERAGING

NOAA FORM 24-13 72

C. DATA FORMAT

This information is requested only for data transmitted on punched cards or magnetic tape. Have one of your data processing specialists furnish answers either on the form or by attaching equivalent readily available documentation. Identify the nature and meaning of all entries and explain any codes used.

1. List the record types contained in your file transmittal (e.g., tape label record, master, detail, standard depth, etc.).

2. Describe briefly how your file is organized.

3-13. Self-explanatory.

14. Enter the field name as appropriate (e.g., header information, temperature, depth, salinity.

15. Enter starting position of the field.

16. Enter field length in number columns and unit of measurement (e.g., bit, byte, character, word) in unit column.

17. Enter attributes as expressed in the programming language specified in item 3 (e.g., "F 4.1," "BINARY FIXED (5.1)").

18. Describe field. If sort field, enter "SORT 1" for first, "SORT 2" for second, etc. If field is repeated, state number of times it is repeated.

C. DATA FORMAT

COMPLETE THIS SECTION FOR PUNCHED CARDS OR TAPE, MAGNETIC TAPE, OR DISC SUBMISSIONS.

---

1. LIST RECORD TYPES CONTAINED IN THE TRANSMITTAL OF YOUR FILE
GIVE METHOD OF IDENTIFYING EACH RECORD TYPE

2. GIVE BRIEF DESCRIPTION OF FILE ORGANIZATION

3. ATTRIBUTES AS EXPRESSED IN ☐ PL-1 ☐ ALGOL ☐ COBOL
☐ FORTRAN ☐ ____________ LANGUAGE

4. RESPONSIBLE COMPUTER SPECIALIST:
NAME AND PHONE NUMBER ____________
ADDRESS ____________

COMPLETE THIS SECTION IF DATA ARE ON MAGNETIC TAPE

5. RECORDING MODE
☐ BCD ☐ BINARY
☐ ASCII ☐ EBCDIC
☐ ____________

6. NUMBER OF TRACKS (CHANNELS)
☐ SEVEN
☐ NINE
☐ ____________

7. PARITY
☐ ODD
☐ EVEN

8. DENSITY
☐ 200 BPI ☐ 1600 BPI
☐ 556 BPI
☐ 800 BPI
☐ ____________

9. LENGTH OF INTER-RECORD GAP (IF KNOWN)
☐ 3/4 INCH
☐ ____________

10. END OF FILE MARK
☐ OCTAL 17
☐ ____________

11. PASTE-ON-PAPER LABEL DESCRIPTION *(INCLUDE ORIGINATOR NAME AND SOME LAY SPECIFICATIONS OF DATA TYPE, VOLUME NUMBER)*

12. PHYSICAL BLOCK LENGTH IN BYTES

13. LENGTH OF BYTES IN BITS

NOAA FORM 24-13

RECORD FORMAT DESCRIPTION

RECORD NAME ____________________

14. FIELD NAME	15. POSITION FROM - 1 MEASURED IN ______ (e.g., bits, bytes)	16. LENGTH		17. ATTRIBUTES	18. USE AND MEANING
		NUMBER	UNITS		

RECORD FORMAT DESCRIPTION

RECORD NAME ______________________________

14. FIELD NAME	15. POSITION FROM-1 MEASURED IN ________ (e.g., bits, bytes)	16. LENGTH		17. ATTRIBUTES	18. USE AND MEANING
		NUMBER	UNITS		

NOAA FORM 24-13

RECORD FORMAT DESCRIPTION

RECORD NAME ______________________________

14. FIELD NAME	15. POSITION FROM-1 MEASURED IN ______ (e.g., bits, bytes)	16. LENGTH		17. ATTRIBUTES	18. USE AND MEANING
		NUMBER	UNITS		

NOAA FORM 24-13

RECORD FORMAT DESCRIPTION

RECORD NAME ____________________

14. FIELD NAME	15. POSITION FROM-1 MEASURED IN ______ (e.g., bits, bytes)	16. LENGTH		17. ATTRIBUTES	18. USE AND MEANING
		NUMBER	UNITS		

NOAA FORM 24-13

D. INSTRUMENT CALIBRATION

This calibration information will be utilized by NOAA's National Oceanographic Instrumentation Center in their efforts to develop calibration standards for voluntary acceptance by the oceanographic community. Identify the instruments used by your organization to obtain the scientific content of the DDF (i.e., STD, temperature and pressure sensors, salinometers, oxygen meters, velocimeters, etc.) and furnish the calibration data requested by completing and/or checking ("✓") the appropriate spaces. Add the interval time (i.e., 3 months, 6 months, 9 months, etc.) if the fixed interval calibration cycle is checked.

INSTRUMENT TYPE (MFR., MODEL NO.)	DATE OF LAST CALIBRATION	INSTRUMENT WAS CALIBRATED BY		CHECK ONE: INSTRUMENT IS CALIBRATED					INSTRUMENT IS NOT CALIBRATED (√)
		YOUR ORGANIZATION (√)	OTHER ORGANIZATION (GIVE NAME)	AT FIXED INTERVALS (√)	BEFORE OR AFTER USE (√)	BEFORE AND AFTER USE (√)	ONLY AFTER REPAIR (√)	ONLY WHEN NEW (√)	

NOAA FORM 24-13

APPENDIX 2

DATA ACQUISITION FORMS

TASK	LOAD FORM TITLE
2.3.4	Shrimp Bioassay
2.3.5	EPA Fauna Survey Reef Fish Census Pelagic Fish Census Stomach Contents Brine Dye Release Fish Bioassay
2.3.6	EPA Ichthyoplankton Survey
2.3.7	Bacteria - Behavior Bacteria - Degradation Rates Bacteria - Enumeration Bacteria - Taxonomy/Physiological Diversity
2.3.8	Respirometry Experiment Fish Recapture Fish Tagging Bio-fouling Food Habits Food Habits - Stomach Contents
2.3.9	Drift Bottle Release/Recovery Log Dye Study Transponding Buoy
2.4.1	Hydrocarbons
2.4.2	Trace Metals in Organisms, Sediment, and Water

TASK 2.3.4

SHRIMP BIOASSAY

SHRIMP BIOASSAY

FILE TYPE	RECORD TYPE	EXPERIMENT					SPECIES	SIZE	DATE			TIME	SOURCE	SALINITY (PPT)	TEMP (°C)	CONDITION	VOLUME (ML)	CONCENTRATION (PPM)	PETROLEUM	PERCENT	NUMBER CONTAINERS	
		NUMBER	SEGMENT	DATE																		
				MO	DAY	YR			MO	DAY	YR											
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17	18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35	36	37 38	39 40	41 42	43 44 45 46	47 48 49 50 51 52	53 54 55 56	57 58 59 60	61 62	63 64 65 66	67 68 69 70 71 72	73	74 75	76 77	78 79 80
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FILE TYPE	RECORD TYPE	EXPERIMENT NUMBER	SEGMENT	DATE		TIME	WATER CODE	CONTAINER 1					CONTAINER 2					CONTAINER 3					CONTAINER 4					CONTAINER 5					CONTAINER 6				
				MO	DAY			OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MARIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT
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SHRIMP BIOASSAY

FILE TYPE	RECORD TYPE	EXPERIMENT NUMBER	SEGMENT	DATE		TIME	WATER CODE	CONTAINER 7					CONTAINER 8					CONTAINER 9					CONTAINER 10					CONTAINER 11					CONTAINER 12				
				MO	DAY			OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT	OK	DEAD	MORIBUND	STRESS	MOLT
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SHRIMP BIOASSAY

FILE TYPE	RECORD TYPE	EXPERIMENT					CONTAINER	NUMBER MEASURED	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	LENGTH (MM)	
		NUMBER	SEGMENT	DATE																			
				MO	DAY	YR																	
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SHRIMP BIOASSAY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File Type "80" constant
Record Type	3	1	I1	Record Type "1" constant
Experiment Number	4	6	A6	Experiment number (right justified)
Experiment Segment	10	2	I2	Experiment segment
Experiment Date	12	6	3I2	Month, day, and last two digits of year
Species	18	18	3A6	Species (left justified)
Species size	36	1	I1	Size Code 1 = Large 2 = Small 3 = Medium 4 = Mixed
Sample Date	37	6	3I2	Month, day and last two digits of year
Sample Time	43	4	I4	Time of sample - 24 hour clock
Sample Source	47	6	A6	Source Code PLTF A = Platform A PLTF B = Platform B BRINE = Brine MIXED = Mixed Brine WATER = Water (control) SUFORN = Sufornate (control)
Sample Salinity	53	4	F4.1	Salinity of sample (ppt) to tenths (decimal included)
Sample Temperature	57	4	F4.1	Temperature of sample (°C) to tenth (decimal included)
Sample Condition	61	2	I2	Code 1 = Clear 2 = Black 3 = Yellow

SHRIMP BIOASSAY (Continued)

Field Name	Position	Length	Format	Use and Meaning
Sample Volume	63	4	I4	Volume of sample in each container (ml)
Sample Concentration	67	6	F6.1	Concentration (ppm) (decimal included)
Petroleum	73	1	A1	Code P = Petroleum added
Percent	74	3	I2	Percent petroleum
Containers	76	2	I2	Number of containers

SHRIMP BIOASSAY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File Type "80" constant
Record Type	3	1	I1	Record type "3" constant
Experiment Number	4	6	A6	Experiment Number (right justified)
Experiment Segment	10	2	I2	Experiment Segment
Experiment Date	12	4	2I2	Month and day
Time	16	4	I4	Time - 24 hour clock
Water Code	20	1	I1	1 = Water changed
		Container 7		
OK	21	2	I2	Number OK
Dead	23	2	I2	Number dead
Moribund	25	2	I2	Number moribund
Stress	27	2	I2	Number stress
Molt	29	2	I2	Number molt
		Container 8		
OK	31	2	I2	same as col. 21-30
Dead	33	2	I2	
Moribund	35	2	I2	
Stress	37	2	I2	
Molt	39	2	I2	

SHRIMP BIOASSAY (Continued)

Field Name	Position	Length	Format	Use and Meaning
OK	41	2	I2	Same as col. 21-30
Dead	43	2	I2	
Moribund	45	2	I2	
Stress	47	2	I2	
Molt	49	2	I2	
		Container 10		
OK	51	2	I2	Same as col. 21-30
Dead	53	2	I2	
Moribund	55	2	I2	
Stress	57	2	I2	
Molt	59	2	I2	
		Container 11		
OK	51	2	I2	Same as col. 21-30
Dead	63	2	I2	
Moribund	65	2	I2	
Stress	67	2	I2	
Molt	69	2	I2	

SHRIMP BIOASSAY (Continued)

Field Name	Position	Length	Format	Use and Meaning
		Container 12		
OK	71	2	I2	Same as col. 21-30
Dead	73	2	I2	
Moribund	75	2	I2	
Stress	77	2	I2	
Molt	79	2	I2	

SHRIMP BIOASSAY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File Type "80" constant
Record Type	3	1	I1	Record Type "2" constant
Experiment Number	4	6	A6	Experiment Number (right justified)
Experiment Segment	10	2	I2	Experiment Segment
Experiment Date	12	4	2I2	Month and day
Time	16	4	I4	Time - 24 hour clock
Water Code	20	1	I1	Code 1 = water changed
		Container 1		
OK	21	2	I2	Number OK
Dead	23	2	I2	Number dead
Moribund	25	2	I2	Number moribund
Stress	27	2	I2	Number stress
Molt	29	2	I2	Number molt
		Container 2		
OK	31	2	I2	same as col. 21-30
Dead	33	2	I2	
Moribund	35	2	I2	
Stress	37	2	I2	
Molt	39	2	I2	

SHRIMP BIOASSAY (Continued)

Field Name	Position	Length	Format	Use and Meaning
		Container 3		
OK	41	2	I2	Same as col. 21-30
Dead	43	2	I2	
Moribund	45	2	I2	
Stress	47	2	I2	
Molt	49	2	I2	
		Container 4		
OK	51	2	I2	Same as col. 21-30
Dead	53	2	I2	
Moribund	55	2	I2	
Stress	57	2	I2	
Molt	59	2	I2	
		Container 5		
OK	51	2	I2	Same as col. 21-30
Dead	63	2	I2	
Moribund	65	2	I2	
Stress	67	2	I2	
Molt	69	2	I2	

SHRIMP BIOASSAY (Continued)

Field Name	Position	Length	Format	Use and Meaning
		Container 6		
OK	71	2	I2	Same as col. 21-30
Dead	73	2	I2	
Moribund	75	2	I2	
Stress	77	2	I2	
Molt	79	2	I2	

SHRIMP BIOASSAY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File Type "80" constant
Record Type	3	1	I1	Record Type "4" constant
Experiment Number	4	6	Ab	Experiment number (right justified)
Experiment Segment	10	2	I2	Experiment segment
Experiment Date	12	6	3I2	Month, day and last two digits of year
Container Number	18	2	I2	Number of container
Number Measured	20	2	I2	Number of individuals measured
Length	22	4	F4.1	Length of first measured individual (in mm) to tenths (decimal included)
Length	26	4	F4.1	Length of second measured individual (in mm) to tenths (decimal included)
Length	30	4	F4.1	Length of third measured individual (in mm) to tenth (decimal included)

*Up to 11 additional measurements can be recorded on this form.

TASK 2.3.5

FISH AND MACROCRUSTACEANS

EPA FAUNA SURVEY

DATA SOURCE CODE	CARD TYPE	DATE			STATION NUMBER	LATITUDE			LONGITUDE			TIME				SAMPLE DEPTH (M)	GEAR TYPE	GEAR CODE	VESSEL SPEED (KNOTS)	TOTAL NUMBER CAUGHT	TOTAL WEIGHT (KG)	NUMBER OF DIFFERENT SPECIES	SUBSAMPLE WEIGHT (KG)	
												START		DURATION										
		MO	DAY	YR		DEG	MIN	SEC	DEG	MIN	SEC	HR	MIN	HR	MIN									
1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34 35 36	37 38	39 40	41 42	43 44 45 46	47 48 49 50 51 52 53 54	55 56 57	58 59 60 61 62 63 64	65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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NFEL NO. 101 REV. 2

EPA FAUNA SURVEY

DATA SOURCE CODE	CARD TYPE	DATE			STATION NUMBER	SPECIES SAMPLE NUMBER	SPECIES	GEAR TYPE	GEAR CODE	SPECIES WEIGHT (GMS)	MEASURED INDIVIDUALS												NUMBER IN SAMPLE
		MO	DAY	YR							SEX	LENGTH (MM)	WEIGHT (GMS)	SEX	LENGTH (MM)	WEIGHT (GMS)	SEX	LENGTH (MM)	WEIGHT (GMS)	SEX	LENGTH (MM)	WEIGHT (GMS)	
1 2	3	4 5	6 7	8 9	10 11 12	13 14 15	16 17 18 19 20 21 22 23 24 25	26	27	28 29 30 31 32	33	34 35 36 37 38	39 40 41 42 43	44	45 46 47 48 49	50 51 52 53 54	55	56 57 58 59 60	61 62 63 64 65	66	67 68 69 70 71	72 73 74 75 76	77 78 79 80
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NFEL 102 REV. 4

EPA FAUNA SURVEY

		DATE					MEASURED INDIVIDUALS																	
DATA SOURCE CODE	CARD TYPE	MO	DAY	YR	STATION NUMBER	SPECIES SAMPLE NUMBER	SEX	LENGTH (MM)	WEIGHT (GMS)	SEX	LENGTH (MM)	WEIGHT (GMS)	SEX	LENGTH (MM)	WEIGHT (GMS)	SEX	LENGTH (MM)	WEIGHT (GMS)	SEX	LENGTH (MM)	WEIGHT (GMS)	GEAR TYPE	GEAR CODE	
1 2	3	4 5	6 7	8 9	10 11 12	13 14 15	16	17 18 19 20 21	22 23 24 25 26	27	28 29 30 31 32	33 34 35 36 37	38	39 40 41 42 43	44 45 46 47 48	49	50 51 52 53 54	55 56 57 58 59	60	61 62 63 64 65	66 67 68 69 70	71	72	73 74 75 76 77 78 79 80
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NFEL 103 REV. 3

EPA FAUNA SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"57" (constant)
Card Type	3	1	I1	"1" (constant)
Date	4	6	3I2	Month, day, year
Station Number	10	3	A3	Station Number
Latitude	13	6	3I2	Degrees, minutes, seconds
Longitude	19	6	3I2	Degrees, minutes, seconds
Start Time	25	4	I4	Time - 24 hour clock
Durating Time	29	4	2I2	Duration in hours and minutes
Sample Depth	33	4	F4.1	Sample depth in meters to tenths
Gear Type	37	2	I2	Gear Type = 1 Trawling = 4 Trolling = 2 Trapping = 5 Gillnetting = 3 Longlining = 7 Air-lift
Gear Code	39	2	I2	Trapping = 1 Bottom Trap = 2 Floating Trap
Vessel Speed	41	2	I2	Vessel speed in knots
Total Number Caught	43	4	I4	Total number of individuals caught
Total Weight	47	8	F8.1	Weight of catch in kilograms to tenths
Number of Species	55	3	I3	Number of different species in catch
Subsample Weight	58	7	F7.1	Weight in subsample in kilograms to tenths

EPA FAUNA SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"57" (constant)
Card Type	3	1	I1	"2" (constant)
Date	4	6	3I2	Month, day, year
Station Number	10	3	A3	Station Number - (Same as on Type 1 card)
Species Sample Number	13	3	I3	Sample number of species
Species	16	10	A6A4	Species identification
Gear Type	26	1	I1	Gear Type (same as on Type 1 card)
Gear Code	27	1	I1	Gear Code (same as on Type 1 card)
Species Weight	28	5	F5.1	Total weight of individuals in sample of specified species in grams to tenths

MEASURED INDIVIDUALS

Field Name	Position	Length	Format	Use and Meaning
Sex	33	1	A1	Sex of measured individual F = Female M= Male U = Undetermined
Length	34	5	F5.0	Length of measured individuals in millimeters
Weight	39	5	F5.1	Weight of measured individual in grams to tenths

NOTE: A minus sign in First column of weight field indicates weight in kilograms instead of grams.

Up to three additional length/weight measurements can be entered on this card.

Field Name	Position	Length	Format	Use and Meaning
Number in Sample	77	4	I4	Total number of individuals in sample of specified species

EPA FAUNA SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"57" (constant)
Card Type	3	1	I1	"3" (constant)
Date	4	6	3I2	Month, day, year
Station Number	10	3	A3	Station Number (same as on Type 1 card)
Species Sample Number	13	3	I3	Sample Number of Species (Same as on Type 2 card)

MEASURED INDIVIDUALS

Field Name	Position	Length	Format	Use and Meaning
Sex	16	1	A1	Sex of measured individual F = Female M= Male U = Undetermined
Length	17	5	F5. 0	*Length of measured individual in millimeters
Weight	22	5	F5. 1	Weight of measured individual in grams to tenths

NOTE: A minus sign in first column of weight field indicates weight in kilograms instead of grams. Up to four additional length/weight measurements can be entered on this card.

*As many Type 3 cards can be used as necessary to complete length/weight measurements.

Field Name	Position	Length	Format	Use and Meaning
Gear Type	71	1	I1	Gear Type (Same as on Type 1 card)
Gear Code	72	1	I1	Gear Code (Same as on Type 1 card)

REEF FISH CENSUS

FILE TYPE	RECORD TYPE	EXPERIMENT NUMBER	DATE			PRIMARY LOCATION	STRUCTURE	ELEMENT	STATION	AREA (M²)	TIME	UPPER DEPTH (FT)	LOWER DEPTH (FT)	DIVER	COMMENTS
			MO	DAY	YR										
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17 18 19 20	21	22	23 24	25 26 27 28	29 30 31 32	33 34	35 36	37	38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
5 5	1									.					

FILE TYPE	RECORD TYPE	EXPERIMENT NUMBER	DATE			STATION	TIME	DIVER	BIONUMERIC CODE	NUMBER	COMMON NAME	
			MO	DAY	YR							
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17	18 19 20 21	22	23 24 25 26 27 28 29 30 31	32 33 34 35	36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65	66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
5 5	2											
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1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17	18 19 20 21	22	23 24 25 26 27 28 29 30 31	32 33 34 35	36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65	66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NFEL 108 REV. 1

REEF FISH CENSUS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "55" constant
Record Type	3	1	I1	Record type - "1" constant
Experiment Number	4	6	A6	Experiment number (right justified)
Date	10	6	3I2	Month, day and last two digits of year
Primary Location	16	5	A5	Primary location of sample (code - left justified) PLTF = Platform JCKT = Well jacket CONT = Control satellite
Structure	21	1	A1	Structure name
Element	22	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack
Station	23	2	I2	Station number
Area	25	4	F4.1	Area of control mat in m^2 (decimal included)
Time	30	4	I4	Time - 24-hour clock
Upper Depth	33	2	I2	Upper limit of depth in feet
Lower Depth	35	2	I2	Lower limit of depth in feet
Diver	37	1	I1	Diver

REEF FISH CENSUS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "55" constant
Record Type	3	1	I1	Record type - "2" constant
Experiment Number	4	6	A6	Experiment number (right justified)
Date	10	6	3I2	Month, day and last two digits of year
Station	16	2	I2	Station number
Time	18	4	I4	Time - 24-hour clock
Diver	22	2	I1	Diver
Bionumeric Code	23	9	I9	Bionumeric code of individual 999999999 = unknown
Number	32	4	I4	Number of individuals
Common Name	36	30	5A6	Common name of individual

PELAGIC FISH CENSUS

FILE TYPE	RECORD TYPE	EXPERIMENT NUMBER	DATE MO	DATE DAY	DATE YR	PRIMARY LOCATION	STRUCTURE	ELEMENT	STATION	COMMENTS
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17 18 19 20	21	22	23 24	25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
5,8	1									

FILE TYPE	RECORD TYPE	EXPERIMENT NUMBER	DATE MO	DATE DAY	DATE YR	STATION	TIME	DEPTH (FT)	VOLUME (M³)	BIONUMER CODE	NUMBER	COMMON NAME	
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17	18 19 20 21	22 23	24 25 26 27 28 29	30 31 32 33 34 35 36 37 38	39 40 41 42	43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73 74 75 76 77 78 79 80
5,8	2												
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1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17	18 19 20 21	22 23	24 25 26 27 28 29	30 31 32 33 34 35 36 37 38	39 40 41 42	43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73 74 75 76 77 78 79 80

NFEL 110 REV. 1

PELAGIC FISH CENSUS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "58" constant
Record Type	3	1	I1	Record type - "1" constant
Experiment Number	4	6	A6	Experiment number (right justified)
Date	10	6	3I2	Month, day and last two digits of year
Primary Location	16	5	A5	Primary location of sample (code - left justified) PLTF = Platform JCKT = Well jacket CONT = Control satellite
Structure	21	1	A1	Structure name
Element	22	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack
Station	23	2	I2	Station number

PELAGIC FISH CENSUS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "58" constant
Record Type	3	1	I1	Record type - "2" constant
Experiment Number	4	6	A6	Experiment number (right justified)
Date	10	6	3I2	Month, day and last two digits of year
Station	16	2	I2	Station number
Time	18	4	I4	Time - 24-hour clock
Depth	22	2	I2	Depth in feet
Volume	24	6	I6	Volume of water photographed in m^3
Bionumeric Code	30	9	I9	Bionumeric code of individual 999999999 = unknown
Number	39	4	I4	Number of individuals in photograph
Common Name	43	30	5A6	Common name of individual

STOMACH CONTENTS

FILE TYPE	RECORD TYPE	DATE			STATION NUMBER	LATITUDE			LONGITUDE			TIME	DEPTH (M)	GEAR TYPE	GEAR CODE	SPECIES	NUMBER EXAMINED	COMMENTS
		MO	DAY	YR		DEG	MIN	SEC	DEG	MIN	SEC							
1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26 27 28	29 30 31 32 33	34 35	36 37	38 39 40 41 42 43 44 45 46	47 48 49	50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26 27 28	29 30 31 32 33	34 35	36 37	38 39 40 41 42 43 44 45 46	47 48 49	50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NPEL 100

STOMACH CONTENTS

FILE TYPE	RECORD TYPE	DATE			STATION NUMBER	GEAR TYPE	GEAR CODE	SPECIES	SAMPLE NUMBER	LENGTH (MM)	WEIGHT (GRAMS)	SEX	CONTENTS	ABUNDANCE	WEIGHT (GRAMS)	CONTENTS	ABUNDANCE	WEIGHT (GRAMS)	
		MO	DAY	YR															
1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18 19 20 21 22 23 24 25	26 27 28	29 30 31 32	33 34 35 36 37 38 39	40	41 42 43 44 45	46 47 48 49	50 51 52 53 54 55	56 57 58 59 60	61 62 63 64	65 66 67 68 69 70	71 72 73 74 75 76 77 78 79 80
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1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18 19 20 21 22 23 24 25	26 27 28	29 30 31 32	33 34 35 36 37 38 39	40	41 42 43 44 45	46 47 48 49	50 51 52 53 54 55	56 57 58 59 60	61 62 63 64	65 66 67 68 69 70	71 72 73 74 75 76 77 78 79 80

NFEL 106

STOMACH CONTENTS

FILE TYPE	RECORD TYPE	DATE			STATION NUMBER	GEAR TYPE	GEAR CODE	SPECIES	SAMPLE NUMBER	CONTENTS	ABUNDANCE	WEIGHT (GRAMS)	CONTENTS	ABUNDANCE	WEIGHT (GRAMS)	CONTENTS	ABUNDANCE	WEIGHT (GRAMS)	
		MO	DAY	YR															
1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18 19 20 21 22 23 24 25	26 27 28	29 30 31 32 33	34 35 36 37	38 39 40 41 42 43	44 45 46 47 48	49 50 51 52	53 54 55 56 57 58	59 60 61 62 63	64 65 66 67	68 69 70 71 72 73	74 75 76 77 78 79 80
59	3											.			.			.	
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1 2	3	4 5	6 7	8 9	10 11 12	13 14	15 16	17 18 19 20 21 22 23 24 25	26 27 28	29 30 31 32 33	34 35 36 37	38 39 40 41 42 43	44 45 46 47 48	49 50 51 52	53 54 55 56 57 58	59 60 61 62 63	64 65 66 67	68 69 70 71 72 73	74 75 76 77 78 79 80

NFEL 107

STOMACH CONTENTS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	"59" (constant
Record Type	3	1	I1	"1" (constant)
Date	4	6	3I2	Month, day and last two digits of year
Station Number	10	3	A3	Station Number
Latitude	13	6	3I2	Degrees, minutes, seconds
Longitude	19	6	3I2	Degrees, minutes, seconds
Time	25	4	I4	Time - 24 hour clock
Sample Depth	29	5	F5.1	Sample depth in meters to tenths (decimal included)
Gear Type	34	2	I2	Gear Type - Code = 1 Trawling = 2 Trapping = 3 Longlining = 4 Trolling = 5 Gillnetting = 7 Air-lift
Gear Code	36	2	I2	Gear Code - Code = 1 Bottom Trap = 2 Floating Trap
Species	38	9	I9	Bionumeric code of species
Number Examined	47	3	I3	Total number examined

STOMACH CONTENTS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	"59" (constant)
Record Type	3	1	I1	"2" (constant)
Date	4	6	3I2	Month, day and last two digits of year
Station Number	10	3	A3	Station Number
Gear Type	13	2	I2	Gear Type - Code (Same as on Type 1 record)
Gear Code	15	2	I2	Gear Code - Code (Same as on Type 1 record)
Species	17	9	I9	Bionumeric code of species
Sample Number	26	3	I3	Sample Number
Length	29	4	I4	Length of individual in mm
Weight	33	7	F7.2	Weight of individual in grams to hundreths (decimal included)
Sex	40	1	A1	Sex of individual - Code M = Male F = Female U = Undetermined
Contents	41	5	A5	Stomach contents code
Abundance	46	4	I4	Number Present (-1 = number not available)
Weight	50	6	F6.2	Weight of contents in grams to hundreths (decimal included)
Contents	56	5	A5	Same as col. 41-55
Abundance	61	4	I4	
Weight	65	6	F6.2	

STOMACH CONTENTS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	"59" (constant)
Record Type	3	1	I1	"3" (constant)
Date	4	6	3I2	Month, day, and last two digits of year
Station Number	10	3	A3	Station Number
Gear Type	13	2	I2	Gear Type - Code (Same as on Type 1 record)
Gear Code	15	2	I2	Gear Code - Code (Same as on Type 1 record)
Species	17	9	I9	Bionumeric code of species
Sample Number	26	3	I3	Sample Number
Contents	29	5	A5	Stomach contents code
Abundance	34	4	I4	Number present (-1 = number not available)
Weight	38	6	F6.2	Weight of contents in grams to hundreths (decimal included)
Contents	44	5	A5	Same as col. 29-43
Abundance	49	4	I4	
Weight	53	6	F6.2	
Contents	59	5	A5	Same as col. 29-43
Abundance	64	4	I4	
Weight	68	6	F6.2	

* As many type 3 records can be used as needed to complete stomach contents

BRINE DYE RELEASE

FILE TYPE	RECORD TYPE	DATE MO	DATE DAY	DATE YR	PRIMARY LOCATION	STRUCTURE	ELEMENT	EXPERIMENT NUMBER	EXPERIMENT TYPE	COMMENTS
1 2	3	4 5	6 7	8 9	10 11 12 13 14	15	16	17 18 19 20 21 22	23	24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
5 6	1									

FILE TYPE	RECORD TYPE	EXPERIMENT NUMBER	EXPERIMENT TYPE	DATE MO	DATE DAY	DATE YR	TIME	DEPTH (FEET) LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6	LEG 7	LEG 8	LEG 9	LEG 10	LEG 11	LEG 12	WATER MOVEMENT	COMMENTS
1 2	3	4 5 6 7 8 9	10	11 12	13 14	15 16	17 18 19 20	21 22 23	24 25 26	27 28 29	30 31 32	33 34 35	36 37 38	39 40 41	42 43 44	45 46 47	48 49 50	51 52 53	54 55 56	57 58 59	60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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1 2	3	4 5 6 7 8 9	10	11 12	13 14	15 16	17 18 19 20	21 22 23	24 25 26	27 28 29	30 31 32	33 34 35	36 37 38	39 40 41	42 43 44	45 46 47	48 49 50	51 52 53	54 55 56	57 58 59	60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NFEL 109 REV.

BRINE DYE RELEASE

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "56" constant
Record Type	3	1	I1	Record type - "1" constant
Date	4	6	3I2	Month, day and last two digits of year
Primary Location	10	5	A5	Primary location of sample (Code - left justified) PLTF = Platform JCKT = Well jacket CONT = Control satellite
Structure	15	1	A1	Structure name
Element	16	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack
Experiment Number	17	6	A6	Experiment number (right justified)
Experiment Type	23	1	A1	Experiment type - code C = Greatest concentration P = Greatest penetration

BRINE DYE RELEASE

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "56" constant
Record Type	3	1	I1	Record type - "2" constant
Experiment Number	4	6	A6	Experiment number (right justified)
Experiment Type	10	1	A1	Experiment type - code C = Greatest concentration P = Greatest penetration
Date	11	6	3I2	Month, day and last two digits of year
Time	17	4	I4	Time - 24 hour clock
Leg 1	21	3	I3	Depth in feet at Leg 1
Leg 2	24	3	I3	Depth in feet at Leg 2
Leg 3	27	3	I3	Depth in feet at Leg 3
Leg 4	30	3	I3	Depth in feet at Leg 4
Leg 5	33	3	I3	Depth in feet at Leg 5
Leg 6	36	3	I3	Depth in feet at Leg 6
Leg 7	39	3	I3	Depth in feet at Leg 7
Leg 8	42	3	I3	Depth in feet at Leg 8
Leg 9	45	3	I3	Depth in feet at Leg 9
Leg 10	48	3	I3	Depth in feet at Leg 10
Leg 11	51	3	I3	Depth in feet at Leg 11
Leg 12	54	3	I3	Depth in feet at Leg 12
Water Movement	57	3	A3	General direction of water movement (left justified) N = North SE = Southeast NNW = North-northwest

FISH BIOASSAY

FILE TYPE	RECORD TYPE	EXPERIMENT	START DATE			END DATE			CONTROL AREA			BRINE AREA			FIRST SPECIES					SECOND SPECIES					CONTROL MISSING	BRINE MISSING	
																CONTROL		BRINE			CONTROL		BRINE				
			MO	DAY	YR	MO	DAY	YR	PRIMARY LOCATION	STRUCTURE	ELEMENT	PRIMARY LOCATION	STRUCTURE	ELEMENT	BIONUMERIC CODE	ALIVE	DEAD	ALIVE	DEAD	BIONUMERIC CODE	ALIVE	DEAD	ALIVE	DEAD			
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23 24 25 26	27	28	29 30 31 32 33	34	35	36 37 38 39 40 41 42 43 44	45 46	47 48	49 50	51 52	53 54 55 56 57 58 59 60 61	62 63	64 65	66 67	68 69	70 71	72 73	74 75 76 77 78 79 80
5,4	1																										

FILE TYPE	RECORD TYPE	EXPERIMENT	DATE			TIME	AREA	CONDITION	BIONUMERIC CODE	LENGTH (MM)	WEIGHT (GMS)	SEX	COMMON NAME	
			MO	DAY	YR									
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20	21	22 23 24 25 26 27 28 29 30	31 32 33 34	35 36 37 38 39 40 41 42	43	44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73	74 75 76 77 78 79 80
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1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20	21	22 23 24 25 26 27 28 29 30	31 32 33 34	35 36 37 38 39 40 41 42	43	44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73	74 75 76 77 78 79 80

NFEL 104 REV. 2

FISH BIOASSAY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "54" constant
Record Type	3	1	I1	Record type - "1" constant
Experiment	4	6	A6	Experiment number (right justified)
Start Date	10	6	3I2	Month, day and last two digits of year at start of experiment
End Date	16	6	3I2	Month, day and last two digits of year at end of experiment
CONTROL AREA				
Primary Location	22	5	A5	Primary location of sample (code - left justified) PLTF = Platform JCKT = Well jacket CONT = Control satellite
Structure	27	1	A1	Structure name
Element	28	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack
BRINE AREA				
Primary Location	29	5	A5	Primary location of sample (code - left justified) PLTF = Platform JCKT = Well jacket CONT = Control satellite
Structure	34	1	A1	Structure name
Element	35	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack

FISH BIOASSAY (Cont'd)

Field Name	Position	Length	Format	Use and Meaning
FIRST SPECIES				
Bionumeric Code	36	9	I9	Bionumeric code of first species
Control Alive	45	2	I2	Number alive in control area at end of experiment
Control Dead	47	2	I2	Number dead in control area at end of experiment
Brine Alive	49	2	I2	Number alive in brine area at end of experiment
Brine Dead	51	2	I2	Number dead in brine area at end of experiment
SECOND SPECIES				
Bionumeric Code	53	9	I9	Bionumeric code of second species
Control Alive	62	2	I2	Number alive at end of experiment in control area
Control Dead	64	2	I2	Number dead at end of experiment in control area
Brine Alive	66	2	I2	Number alive at end of experiment in brine area
Brine Dead	68	2	I2	Number dead at end of experiment in brine area
Control Missing	70	2	I2	Number missing at end of experiment in control area
Brine Missing	72	2	I2	Number missing at end of experiment in brine area

FISH BIOASSAY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "54" constant
Record Type	3	1	I1	Record type - "2" constant
Experiment	4	6	A6	Experiment number (right justified)
Date	10	6	3I2	Month, day and last two digits of year
Time	16	4	I4	Time - 24-hour clock
Area	20	1	A1	Area - code B = Brine C = Control
Condition	21	1	A1	Condition of individual - code A = Alive D = Dead
Bionumeric Code	22	9	I9	Bionumeric code of individual
Length	31	4	I4	Length of individual in mm
Weight	35	8	F8. 3	Weight of individual in grams to thousandths (decimal included)
Sex	43	1	A1	Sex of individual - code M = Male F = Female U = Undertmined
Common Name	44	30	5A6	Common name of individual

TASK 2.3.6

ICHTHYOPLANKTON

EPA ICHTHYOPLANKTON SURVEY LOAD FORM

DATA SOURCE CODE	GEAR TYPE CODE	CARD TYPE CODE	CRUISE NUMBER	DATE			LOCATION						TIME				SPECIES	NUMBER OF SPECIMEN	MIN. SIZE	MAX. SIZE	MEAN SIZE	DISPLACEMENT VOLUME	WATER FILTERED	NUMBER OF EGGS	
							LATITUDE			LONGITUDE			START		DURATION										
				DA	MO	YR	O	'	"	O	'	"	HR	MIN	MIN	SEC									
1 2	3 4	5	6 7	8 9	10 11	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35 36 37 38 39 40 41 42 43	44 45 46 47	48 49 50 51	52 53 54 55	56 57 58 59	60 61 62 63	64 65 66 67	68 69 70 71 72 73	74 75 76 77 78 79 80

EPA ICHTHYOPLANKTON SURVEY

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"2" (constant)
Gear Type	3	2	I2	Collection gear = 1 Neuston Net = 2 Bongo Net, 333 μ Mesh = 3 Bongo Net, 505 μ Mesh
Cruise Number	6	2	I2	Cruise Number
Date	8	6	3I2	Day, month, year
Latitude	14	6	3I2	Latitude of sample in degrees, minutes and seconds
Longitude	20	6	3I2	Longitude of sample in degrees, minutes and seconds
Start Time	26	4	I4	24 hour clock
Duration	30	4	2I2	Length of time of tow in minutes and seconds
Species	34	9	I9	Bionumeric code of species
Number of Species	44	4	I4	Number of individuals caught
Minimum Size	48	4	F4.1	Size of smallest individual in millimeters to tehtns
Maximum Size	52	4	F4.1	Size of largest individual in millimeters to tenths
Mean Size	56	4	F4.1	Mean size in millimeters to tenths
Displacement Volume	60	4	F4.1	Displacement volume of plankton sample in millimeters^3 to tenths
Water Filtered	64	4	F4.1	Volume of water filtered during the tow to tenths of a M^3
Number of Eggs	68	6	I6	Number of fish eggs in sample

TASK 2.3.7

BACTERIA

BACTERIA - BEHAVIOR

FILE TYPE	TOXICITY															CHEMOTAXIS																ATTACHMENT STUDIES											
	DATE			INOCULUM	CRUISE	STATION	SOURCE	STRAIN	TOXIC MATERIAL ADDED			TIME	DIFFERENCE FROM ORIGINAL TVC			DATE			CRUISE	STATION	SOURCE	STRAIN	MATERIAL ADDED					TIME	DIFFERENCE FROM ORIGINAL TVC			DATE			INOCULUM	CRUISE	STATION	SOURCE	MATERIAL ADDED		DIFFERENCE FROM ORIGINAL TVC		
	MO	DAY	YR						BRINE DISCHARGE (%)	BUCCANEER CONDENSATE (%)	ROH		SIGN	COUNT ●	EXP.	MO	DAY	YR					ARGININE (%)	DH_2O (%)	GLUCOSE (%)	BUCCANEER CRUDE (%)	BUCCANEER DISCHARGE (%)		SIGN	COUNT ●	EXP.	MO	DAY	YR					BUCCANEER DISCHARGE (%)	BACTRON	SIGN	COUNT ●	EXP.
1	2 3	4 5	6 7	8	9	10	11	12 13 14	15 16	17 18	19	20 21 22 23	24	25 26 27	28 29	30 31	32 33	34 35	36	37	38	39 40 41	42 43	44 45	46 47	48 49	50 51	52 53 54 55	56	57 58 59	60 61	62 63	64 65	66 67	68	69	70	71	72 73	74	75	76 77 78	79 80
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NFEL-11

BACTERIA - BEHAVIOR

Field Name	Position	Length	Format	Use and Meaning
File Type	1	1	I1	File type - "3" constant
		TOXICITY		
Date	2	6	3I2	Month, day and last two digits of year
Inoculum	8	1	A1	Culture - code P = Pure culture M = Mixed culture
Cruise	9	1	I1	Cruise number
Station	10	1	I1	Station number
Source	11	1	A1	Source code T= Top M = Middle B = Bottom S = Sediment
Strain	12	3	I3	Strain code
Brine Discharge Added	15	2	I2	% added *
Buccaneer Condensate Added	17	2	I2	% added *
Bactron Added	19	1	I1	Bactron added O = No 1 = Yes
Time	20	4	I4	Time - 24-hour clock
TVC Count	24	6	A1, F3.1, I2	
- Sign	24	1	A1	TVC sign - = less than original TVC + = more than original TVC
Count	25	3	F3.1	Count value - decimal implied i.e. 237 = 2.37
Exponent	28	2	I2	Exponent
		CHEMOTAXIC		
Date	30	6	3I2	Month, day and last two digits of year
Cruise	36	1	I1	Cruise number

Field Name	Position	Length	Format	Use and Meaning
Station	37	1	I1	Station number
Source	38	1	I1	Source code T = Top M = Middle B = Bottom S = Sediment
Strain	39	3	I3	Strain code
Arginine Added	42	2	I2	% added *
DH_2O Added	44	2	I2	% added *
Glucose Added	46	2	I2	% added *
Buccaneer Crude Added	48	2	I2	% added *
Buccaneer Discharge Added	50	2	I2	% added *
Time	52	4	I4	Time - 24-hour clock
TVC Count	56	6	A1, F3.1, I2	Counts ± original TVC Same as col. 24-29
ATTACHMENT STUDIES				
Date	62	6	3I2	Month, day and last two digits of year
Inoculum	68	1	A1	Culture - code P = Pure culture M = Mixed culture
Cruise	69	1	I1	Cruise number
Station	70	1	I1	Station number
Source	71	1	A1	Source code T = Top M = Middle B = Bottom S = Sediment
Buccaneer Discharge Added	72	2	I2	% added *
Bactron Added	74	1	I1	Code 1 = No 2 = Yes
TVC Count	75	6	A1, F3.1, I2	Counts ± original TVC - same as col. 24-29

* Note - % to nearest whole number (99 = 100%).

BACTERIA - DEGRADATION RATES

FILE TYPE	DATE			INOCULUM	CRUISE	STATION	SOURCE	STRAIN	REACTION MIXTURE		TIME	AMOUNT OF REMAINING HYDROCARBONS (%)																											
	MO	DAY	YR						BUCCANEER CRUDE (%)	BRINE DISCHARGE (%)		C-12	C-13	C-14	C-15	C-16	C-17	C-18	C-19	C-20	C-21	C-22	C-23	C-24	C-25	C-26	C-27	C-28	C-29	C-30	C-31	C-32	C-33	C-34	C-35	C-36	PRISTANE	PHYTANE	
1 2	3 4	5 6	7 8	9	10	11	12	13 14 15	16 17	18 19	20 21 22 23	24 25	26 27	28 29	30 31	32 33	34 35	36 37	38 39	40 41	42 43	44 45	46 47	48 49	50 51	52 53	54 55	56 57	58 59	60 61	62 63	64 65	66 67	68 69	70 71	72 73	74 75	76 77	78 79 80
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NFEL-114

BACTERIA - DEGRADATION RATES

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "61" constant
Date	3	6	3I2	Month, day and last two digits of year
Inoculum	9	1	A1	Culture - code P = Pure culture M = Mixed culture
Cruise	10	1	I1	Cruise number
Station	11	1	I1	Station number
Source	12	1	A1	Source Code T = Top M = Middle B = Bottom S = Sediment
Strain	13	3	I3	Strain code
REACTION MIXTURE				
Buccaneer Crude	16	2	I2	% crude *
Brine Discharge	18	2	I2	% discharge *
Time	20	4	I4	Time - 24-hour clock
AMOUNT OF REMAINING HYDROCARBONS				
C-12	24	2	I2	% *
C-13	26	2	I2	% *
C-14	28	2	I2	% *
C-15	30	2	I2	% *
C-16	32	2	I2	% *
C-17	34	2	I2	% *
C-18	36	2	I2	% *
C-19	38	2	I2	% *
C-20	40	2	I2	% *
C-21	42	2	I2	% *
C-22	44	2	I2	% *
C-23	46	2	I2	% *

Field Name	Position	Length	Format	Use and Meaning
C-24	48	2	I2	% *
C-25	50	2	I2	% *
C-26	52	2	I2	% *
C-27	54	2	I2	% *
C-28	56	2	I2	% *
C-29	58	2	I2	% *
C-30	60	2	I2	% *
C-31	62	2	I2	% *
C-32	64	2	I2	% *
C-33	66	2	I2	% *
C-34	68	2	I2	% *
C-35	70	2	I2	% *
C-36	72	2	I2	% *
Pristane	74	2	I2	% *
Phytane	76	2	I2	% *

* Note - % to nearest whole number (99 = 100%).

BACTERIA - ENUMERATION

FILE TYPE	DATE			CRUISE	STATION	SOURCE	TEMPERATURE (°C)	SALINITY (PPT)	O_2 (PPM)	PH	TVC		OIL DEGRADERS	SULPHUR OXIDIZER	HEAVY METALS (%)		BIOMASS (GC/ML)		KIA								TVC SUSPENDED MATERIAL		TVC FILTERED MATERIAL		
	MO	DAY	YR								COUNT	EXP.			ZN	CHR	COUNT	EXP.	H_2S (%)		SLANT (%)		BUT (%)		GAS (%)		COUNT	EXP.	COUNT	EXP.	
																			+	−	ACID	ALK.	ACID	ALK.	+	−					
1 2	3 4	5 6	7 8	9	10	11	12 13 14	15 16 17	18 19 20	21 22 23	24 25 26	27 28	29 30 31	32 33 34	35 36 37	38 39 40 41	42 43 44	45 46	47 48 49	50 51 52	53 54	55 56 57	58 59 60	61 62	63 64 65	66 67 68	69 70 71	72 73	74 75 76	77 78	79 80
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NFEL-113

BACTERIA - ENUMERATION

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "60" constant
Date	3	6	3I2	Month, day and last two digits of year
Cruise	9	1	I1	Cruise number
Station	10	1	I1	Station number
Source	11	1	A1	Source code T = Top M = Middle B = Bottom S = Sediment
Temperature	12	3	F3.1	Temperature in °C to tenths (implied decimal)
Salinity	15	3	F3.1	Salinity in ppt to tenths (implied decimal)
Dissolved Oxygen	18	3	F3.1	Dissolved oxygen - ppm to tenths (implied decimal)
PH	21	3	F3.1	PH to hundreths - (implied decimal)
TVC	24	5	F3.1, I2	Total viable count Water = #/ml Sediment = #/9 21-24 - count (implied decimal) 26 - exponent
Oil Degraders	29	3	F3.1	Percent oil degraders (implied decimal)
Sulphur Oxidizers	32	3	F3.1	Percent sulphur oxidizers (implied decimal)
Zinc	35	3	F3.1	Percent zinc (implied decimal)
Chrominum	38	4	F4.1	Percent chrominum (implied decimal)
Biomass	42	5	F3.1, I2	Biomass gc/ml 39-41 - count (implied decimal) 42-43 - exponent (negative)

Field Name	Position	Length	Format	Use and Meaning
		KIA		
Hydrogen Sulfide +	47	3	I3	Percent Hydrogen sulfide +
Hydrogen Sulfide -	50	3	I3	Percent hydrogen sulfide -
Slant Acid	53	2	I2	Percent slant acid
Slant Alkaline	55	3	I3	Percent slant alkaline
But Acid	58	3	I3	Percent but acid
But Alkaline	61	2	I2	Percent but alkaline
Gas +	63	3	I3	Percent gas +
Gas -	66	3	I3	Percent gas -
TVC Suspended Material	69	5	F3.1, I2	Total viable count of suspended material same as col. 24-28
TVC Filtered Material	74	5	F3.1, I2	Total viable count of filtered material same as col. 24-28

BACTERIA - TAXONOMY/PHYSIOLOGICAL DIVERSITY

FILE TYPE	TAXONOMY																				PHYSIOLOGICAL DIVERSITY						
	DATE			CRUISE	STATION	SOURCE	STRAIN	GRAM STAIN	MOF	MOF + GAS	MOTILITY	FLAGELLA STAIN	OXIDASE	CATALASE	CELL SHAPE	SPORE	O/129 SENSITIVITY	ARGININE DECARBOXYLASE	FLUOR. PIG. FORMED	GENERA	PROTEOLYTIC	CHITINOCLASTIC	LIPOLYTIC	SALT REQ	AMYLASE	CELLULOLYTIC	
	MO	DAY	YR																								
1 2	3 4	5 6	7 8	9	10	11	12 13 14	15	16	17	18	19	20	21	22	23	24	25	26	27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68	69	70	71	72	73	74	75 76 77 78 79 80
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NPEL-118

BACTERIA - TAXONOMY/PHYSIOLOGICAL DIVERSITY

Field Name	Postition	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "62" constant
		TAXONOMY		
Date	3	6	3I2	Month, day and last two digits of year
Cruise	9	1	I1	Cruise number
Station	10	1	I1	Station number
Source	11	1	A1	Source code T= Top M = Middle B = Bottom S = Sediment
Strain	12	3	I3	Strain code
Gram Stain	15	1	I1	Code O = - 1 = +
MOF	16	1	I1	MOF code 1 = Fermentative 2 = Oxidative 3 = Alkaline 4 = No reaction
MOF + Gas	17	1	I1	Code O = - 1 = +
Motility	18	1	I1	Code O = - 1 = +
Flagella Stain	19	1	I1	Code 1 = Polar 2 = Peritrichous
Oxidase	20	1	I1	Code O = - 1 = +

Field Name	Position	Length	Format	Use and Meaning
Catalase	21	1	I1	Code O = - 1 = +
Cell Shape	22	1	I1	Code 1 = Rods 2 = Spheres 3 = Straight 4 = Curve 5 = Other
Spore	23	1	I1	Code O = - 1 = +
0/129 Sensitivity	24	1	I1	Code O = - 1 = +
Arginine Decarboxylase	25	1	I1	Code O = - 1 = +
Fluorescent Pigment Formed	26	1	I1	Code O = - 1 = +
Genera Designation	27	42	7A6	Genera
	PHYSIOLOGICAL DIVERSITY			
Proteolytic	69	1	I1	Code O = - 1 = +
Chitinoclastic	70	1	I1	Code O = - 1 = +
Lipolytic	71	1	I1	Code O = - 1 = +
Salt Reg.	72	1	I1	Code O = - 1 = +

Field Name	Position	Length	Format	Use and Meaning
Amylase	73	1	I1	Code 0 = - 1 = +
Cellulolytic	74	1	I1	Code 0 = - 1 = +

TASK 2.3.8

EFFECTS OF STRUCTURES

RESPIROMETRY EXPERIMENT

FILE TYPE	RECORD TYPE	DATE			PRIMARY LOCATION	STRUCTURE	ELEMENT	STATION NUMBER	EXPERIMENT	DEPTH (FT)	WATER (GAL)	WEATHER CONDITIONS				WATER CONDITIONS		COMMENTS
		MO	DAY	YR								CLOUDCOVER	PRECIP	WIND DIRECTION	WIND SPEED (MPH)	SEAS (FT)	TURBIDITY	
1 2	3	4 5	6 7	8 9	10 11 12 13 14	15	16	17 18 19	20 21 22 23 24 25	26 27	28 29 30 31	32	33	34 35 36	37 38 39 40	41 42 43 44	45	46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
7, 3	1																	

FILE TYPE	RECORD TYPE	DATE			EXPERIMENT	TIME	DISSOLVED OXYGEN (PPM)	PHOTOMETER	SALINITY (PPT)	TEMPERATURE (°C)	TIME	DISSOLVED OXYGEN (PPM)	PHOTOMETER	SALINITY (PT	TEMPERATURE (°C)	
		MO	DAY	YR												
1 2	3	4 5	6 7	8 9	10 11 12 13 14 15	16 17 18 19	20 21 22 23 24	25 26 27 28 29	30 31 32 33	34 35 36 37	38 39 40 41	42 43 44 45 46	47 48 49 50 51	52 53 54 55	56 57 58 59	60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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RESPIROMETRY EXPERIMENT

Field Name	Position	Length	Format	Use and Meaning
File type	1	2	I2	File type - "73" constant
Record Type	3	1	I1	Record type - "1" constant
Date	4	6	312	Month, day and last two digits of year
Primary Location	10	5	A5	Primary Location of sample (Code - left justified) PLTF = Platform JCKT = Well Jacket CONT = Control Satellite FIELD = Field Station
Structure	15	1	A1	Structure name (not used with field stations)
Element	16	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack (not used with field stations)
Station Number	17	3	A3	Field Station number (used only with field stations)
Experiment	20	6	A6	Experiment number
Depth	26	2	I2	Depth in feet
Water	28	4	I4	Number of gallons of water flushed through dome
WEATHER CONDITIONS				
Cloud Cover	32	1	I1	Cloud cover - code 1 = Clear 2 = Partly cloudy 3 = Cloudy 4 = Fog 5 = Overcast
Precipitation	33	1	I1	Precipitation - code 1 = Rain 0 = No rain

RESPIROMETRY EXPERIMENT

Field Name	Position	Length	Format	Use and Meaning
Wind Direction	34	3	A3	Wind direction - compass point (left justified) e.g. W = West SE = Southeast NNE = North, Northeast
Wind Speed	37	4	2I2	Wind speed in mph. Col. 37, 38 = lower limit Col. 39, 40 = upper limit
WATER CONDITIONS				
Seas	41	4	2I2	Wave height in feet. Col. 41, 42 = lower limit Col. 43, 44 = upper limit
Turbidity	45	1	I1	Water turbidity - code 1 = Clear 2 = Turbid - good visibility 3 = Turbid - normal visibility 4 = Turbid - poor visibility
Comments	46	24	4A6	Comments (if any)

RESPIROMETRY EXPERIMENT

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "73" constant
Record Type	3	1	I1	Record type - "2" constant
Date	4	6	3I2	Month, day and last two digits of year
Experiment	10	6	A6	Experiment number
Time	16	4	I4	Time - 24 hour clock
Dissolved Oxygen	20	5	F5.1	Dissolved Oxygen in ppm to tenths (decimal included)
Photometer	25	5	F5.2	Radiance value - to hundreths (decimal included)
Salinity	30	4	F4.1	Salinity in ppt to tenths (decimal included)
Temperature	34	4	F4.1	Temperature in °C to tenths (decimal included)
Time	38	4	I4	Repeat column 16 to 37
Dissolved Oxygen	42	5	F5.1	
Photometer	47	5	F5.2	
Salinity	52	4	F4.1	
Temperature	56	4	F4.1	

FISH RECAPTURE

FILE TYPE	RECORD TYPE	DATE			PRIMARY LOCATION	STRUCTURE	ELEMENT	STATION NUMBER	START TIME	END TIME	TAG COLOR	TAG NUMBER	COMMON NAME	SCIENTIFIC NAME	
		MO	DAY	YR											
1 2	3	4 5	6 7	8 9	10 11 12 13 14	15	16	17 18 19	20 21 22 23	24 25 26 27	28 29	30 31 32 33 34	35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52	53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79	80
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FISH RECAPTURE

Field Name	Position	Length	Format	Use and Meaning
File type	1	2	I2	File type - "70" constant
Record Type	3	1	I1	Record type - "3" constant
Date	4	6	3I2	Month, day and last two digits of year
Primary Location	10	5	A5	Primary Location of sample (Code - left justified) PLTF = Platform JCKT = Well Jacket CONT = Control Satellite FIELD = Field Station
Structure	15	1	A1	Structure name (not used with field stations)
Element	16	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack (not used with field stations)
Station Number	17	3	A3	Field Station number (used only with field stations)
Start Time	20	4	I4	24 hour clock
End Time	24	4	I4	24 hour clock
Tag Color	28	2	I2	Tag color - code 1 = Red 2 = White 3 = Blue 4 = Green 5 = Yellow 6 = Black
Tag Number	30	5	A5	Tag Number (right justified)
Common Name	35	18	3A6	Common name of sample (left justified)
Scientific Name	53	27	4A6, A3	Scientific name of sample (left justified)

FISH TAGGING

FILE TYPE	RECORD TYPE	DATE			PRIMARY LOCATION	STRUCTURE	ELEMENT	STATION NUMBER	START TIME	END TIME	UPPER DEPTH (FT)	LOWER DEPTH (FT)	CAPTURE	BAIT	TAG COLOR	COMMON NAME	SCIENTIFIC NAME
		MO	DAY	YR													
1 2	3	4 5	6 7	8 9	10 11 12 13 14	15	16	17 18 19	20 21 22 23	24 25 26 27	28 29 30	31 32 33	34	35	36 37	38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
7 0	1																

FILE TYPE	RECORD TYPE	TAG NUMBER	LENGTH (MM)	TAG NUMBER	LENGTH (MM)	TAG NUMBER	LENGTH (MM)	TAG NUMBER	LENGTH (MM)	TAG NUMBER	LENGTH (MM)	TAG NUMBER	LENGTH (MM)	TAG NUMBER	LENGTH (MM)	TAG NUMBER	LENGTH (MM)	
1 2	3	4 5 6 7 8	9 10 11 12	13 14 15 16 17	18 19 20 21	22 23 24 25 26	27 28 29 30	31 32 33 34 35	36 37 38 39	40 41 42 43 44	45 46 47 48	49 50 51 52 53	54 55 56 57	58 59 60 61 62	63 64 65 66	67 68 69 70 71	72 73 74 75	76 77 78 79 80
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FISH TAGGING

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - 70" constant
Record Type	3	1	I1	Record type - 1" constant
Date	4	6	3I2	Month, day and last two digits of year
Primary Location	10	5	A5	Primary Location of Sample (Code - left justified) PLTF = Platform JCKT = Well Jacket CONT = Control Satellite FIELD = Field Station
Structure	15	1	A1	Structure name (not used with field stations)
Element	16	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack (not used with field stations)
Station Number	17	3	A3	Field station number (used only with field stations)
Start Time	20	4	I4	24 hour clock
End Time	24	4	I4	24 hour clock
Upper Depth	28	3	I3	Upper depth level of capture (feet)
Lower Depth	31	3	I3	Lower depth level of capture (feet)
Capture	34	1	I1	Method of capture - code 1 = Hook and line 2 = Trap 3 = Spear 4 = Trawl 5 = Diver 6 = Slurp Gun
Bait	35	1	I1	Bait - code 1 = Shrimp

FISH TAGGING

Field Name	Position	Length	Format	Use and Meaning
Tag Color	36	2	I2	Tag color - code 1 = Red 2 = White 3 = Blue 4 = Green 5 = Yellow 6 = Black
Common Name	38	16	2A6, A4	Common name of sample (left justified)
Scientific Name	54	27	4A6, A3	Scientific name of sample (left justified)
File Type	1	2	I2	File type - "70" constant
Record Type	3	1	I1	Record type - "2" constant
Tag Number	4	5	A5	Tag number (right justified)
Length	9	4	I4	Length of measured individual (mm)
Tag Number	13	5	A5	Same as col. 4-12
Length	18	4	I4	
Tag Number	22	5	A5	Same as col. 4-12
Length	27	4	I4	
Tag Number	31	5	A5	Same as col. 4-12
Length	36	4	I4	
Tag Number	40	5	A5	Same as col. 4-12
Length	45	4	I4	
Tag Number	49	5	A5	Same as col. 4-12
Length	54	4	I4	
Tag Number	58	5	A5	Same as col. 4-12
Length	63	4	I4	
Tag Number	67	5	A5	Same as col. 4-12
Length	72	4	I4	

BIO-FOULING

FILE TYPE		DATE MO	DATE DAY	DATE YR	PRIMARY LOCATION	STRUCTURE	ELEMENT	EXPERIMENT	WEIGHT (GRAMS)	SHELL	HYDROID	ENCRUSTING SPONGE	ENCRUSTING BRYOZOAN	STALKED BRYOZOAN	ALGAE	OTHER	COMMENTS	HYDROID	ENCRUSTING SPONGE	ENCRUSTING BRYOZOAN	STALKED BRYOZOAN	ALGAE	OTHER	COMMENTS
1 2	3	4 5	6 7	8 9	10 11 12 13 14	15	16	17 18 19 20 21 22	23 24 25 26 27	28 29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48	49 50 51 52 53 54 55	56 57 58	59 60 61	62 63 64	65 66 67	68 69 70	71 72 73	74 75 76 77 78 79 80
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BIO-FOULING

FILE TYPE	RECORD TYPE	DATE			EXPERIMENT	VIAL	TAXA	NUMBER	WEIGHT (MG)	
		MO	DAY	YR						
1 2	3	4 5	6 7	8 9	10 11 12 13 14 15	16 17	18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65	66 67 68	69 70 71 72 73 74	75 76 77 78 79 80
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1 2	3	4 5	6 7	8 9	10 11 12 13 14 15	16 17	18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65	66 67 68	69 70 71 72 73 74	75 76 77 78 79 80

BIOFOULING

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "72" Constant
Record Type	3	1	I1	Record Type - "1" Constant
Date	4	6	3I2	Month, Day and last two digits of year
Primary Location	10	5	A5	Primary Location of sample (Code - left justified) PLTF = Platform JCKT = Well Jacket CONT = Control Satellite FIELD = Field Station
Structure	15	1	A1	Structure name (not used with field stations)
Element	16	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack (not used with field stations)
Experiment	17	6	A6	Experiment number (left justified)
Weight	23	5	F5.1	Total wet weight in grams to tenths (decimal included)
Shell	28	3	I3	Percent shell weight
Hydroid	31	3	I3	Percent Hydroid composing experiment
Encrusting Sponge	34	3	I3	Percent Encrusting Sponge composing experiment
Encrusting Bryozoan	37	3	I3	Percent Encrusting Bryozoan composing experiment
Stalked Bryozoan	40	3	I3	Percent Stalked Bryozoan composing experiment
Algae	43	3	I3	Percent Algae composing experiment
Other	46	3	I3	Percent other taxa composing experiment
Comments	49	7	A6,A1	Comments on other field.

BIOFOULING

Field Name	Position	Length	Format	Use and Meaning
--The following should be completed only when using both top and bottom measurements.				
Hydroid	55	3	I3	Same as Col. 31-55
Encrusting Sponge	59	3	I3	
Encrusting Bryozoan	61	3	I3	
Stalked Bryozoan	64	3	I3	
Algae	68	3	I3	
Other	71	3	I3	
Comments	74	7	A6,A1	

*Note - A minus sign in first column of Percent field indicates measurement is less than recorded measurement.
(i.e. -10 means < 10%)

BIOFOULING

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "72" constant
Record Type	3	1	I1	Record type - "2" constant
Date	4	6	3I2	Month, day and last two digits of year
Experiment	10	6	A6	Experiment number (left justified)
Vial	16	2	A2	Vial number (left justified)
Taxa	18	48	8A6	Taxa (right justified)
Number	66	3	I3	Number of individuals
Weight	69	6	F6.1	Total wet weight of individuals in mg to tenths (decimal included)

FOOD HABITS

FILE TYPE	RECORD TYPE	DATE			PRIMARY LOCATION	STRUCTURE	ELEMENT	STATION NUMBER	COMMON NAME	SCIENTIFIC NAME	
		MO	DAY	YR							
1 2	3	4 5	6 7	8 9	10 11 12 13 14	15	16	17 18 19	20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37	38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64	65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
7,1	1										

FILE TYPE	RECORD TYPE	SAMPLE NUMBER	TIME CAUGHT	TIME SACRIFIC-ED	LENGTH (MM)	WEIGHT (GRAMS)	SEX	SAMPLE NUMBER	TIME CAUGHT	TIME SACRIFIC-ED	LENGTH (MM)	WEIGHT (GRAMS)	SEX	SAMPLE NUMBER	TIME CAUGHT	TIME SACRIFIC ED	LENGTH (MM)	WEIGHT (GRAMS)	SEX	
1 2	3	4 5 6 7 8	9 10 11 12	13 14 15 16	17 18 19 20	21 22 23 24	25	26 27 28 29 30	31 32 33 34	35 36 37 38	39 40 41 42	43 44 45 46	47	48 49 50 51 52	53 54 55 56	57 58 59 60	61 62 63 64	65 66 67 68	69	70 71 72 73 74 75 76 77 78 79 80
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FOOD HABITS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "71" constant
Record Type	3	1	I1	Record type - "1" constant
Date	4	6	3I2	Month, day and last two digits of year
Primary Location	10	5	A5	Primary Location of sample (Code - left justified) PLTF = Platform JCKT = Well Jacket CONT = Control Satellite FIELD = Field Station
Structure	15	1	A1	Structure name (not used with field stations)
Element	16	1	A1	Part of structure - code Q = Quarters P = Production F = Flare stack (not used with field stations)
Station Number	17	3	A3	Field Station number (used only with field stations)
Common Name	20	18	3A6	Common name of sample (left justified)
Scientific Name	38	27	4A6, A3	Scientific name of sample (left justified)
File Type	1	2	I2	File type - "71" constant
Record Type	3	1	I1	Record type - "2" constant
Sample Number	4	5	A5	Sample number of individual (right justified)
Time caught	9	4	I4	24 hour clock
Time Sacrificed	13	4	I4	24 hour clock

FOOD HABITS

Field Name	Position	Length	Format	Use and Meaning
Length	17	4	I4	Length of individual (mm)
Weight	21	4	I4	Weight of individual (grams)
Sex	25	1	A1	Sex - code M = male F = female blank - unknown or undetermined
Sample Number	26	5	A5	Same as columns 4-25
Time Caught	31	4	I4	
Time Sacrificed	35	4	I4	
Length	39	4	I4	
Weight	43	4	I4	
Sex	47	1	A1	
Sample Number	48	5	A5	Same as columns 4-25
Time Caught	53	4	I4	
Time Sacrificed	57	4	I4	
Length	61	6	I4	
Weight	65	4	I4	
Sex	69	1	A1	

FOOD HABITS — STOMACH CONTENTS

FILE TYPE	RECORD TYPE	DATE			PRIMARY LOCATION	STRUCTURE	ELEMENT	STATION NUMBER	TIME		BIONUMERIC CODE	SEQUENCE NUMBER	COMMON NAME	LENGTH (MM)	WEIGHT (GRAMS)	SEX	CONTENTS WEIGHT (GRAMS)	
		YR	MO	DAY					START	END								
1 2	3	4 5	6 7	8 9	10 11 12 13 14	15	16	17 18 19	20 21 22 23	24 25 26 27	28 29 30 31 32 33 34 35 36	37 38	39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62	63 64 65 66	67 68 69 70	71	72 73 74 75 76 77	78 79 80
7 7	1																	

FILE TYPE	RECORD TYPE	DATE			BIONUMERIC CODE	SEQUENCE NUMBER	STOMACH CONTENTS TAXA	PERCENT	
		YR	MO	DAY					
1 2	3	4 5	6 7	8 9	10 11 12 13 14 15 16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62	63 64 65	66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
7 7	2								
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1 2	3	4 5	6 7	8 9	10 11 12 13 14 15 16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62	63 64 65	66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NFEL 117

FOOD HABITS - STOMACH CONTENTS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "77" constant
Record Type	3	1	I1	Record type - "1" constant
Date	4	6	3I2	Last two digits of year, month and day
Primary Location	10	5	A5	Primary Location (code - left justified) PLTF = Platform JCKT = Well Jacket CONT = Control Satellite FIELD = Field Station
Structure	15	1	A1	Structure name (not used with field stations)
Element	16	1	A1	Part of structure - code Q = Quarters P = Production F = Flare Stack (not used with field stations)
Station Number	17	3	A3	Field Station number
Start Time	20	4	I4	24 hour clock
End Time	24	4	I4	24 hour clock
Bionumeric Code	28	9	I9	Bionumeric code of individual
Sequence Number	37	2	I2	Sequence number of individual sampled
Common Name	39	24	4A6	Common name of individual
Length	63	4	I4	Length of individual in mm
Weight	67	4	I4	Weight of individual in grams
Sex	71	1	A1	Sex of individual - code M = Male F = Female U = Undetermined
Contents Weight	72	6	I6	Weight of total stomach contents in grams

FOOD HABITS - STOMACH CONTENTS

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type - "77" - constant
Record Type	3	1	I1	Record type - "2" - constant
Date	4	6	3I2	Last two digits of year, month and day
Bionumeric Code	10	9	I9	Bionumeric code of individual
Species Sequence Number	19	2	I2	Sequence number of individual sampled
Stomach Contents Taxa	21	42	7A6	Stomach contents taxa - left justified
Percent	63	3	I3	Percent of total weight of contents comprised by this taxa

TASK 2.3.9

CURRENTS, TEMPERATURE, SALINITY AND CIRCULATION

DRIFT BOTTLE RELEASE RECOVERY LOG

FILE TYPE	CARD TYPE	CRUISE NUMBER	BOTTLE DATA		RELEASE DATA							RECOVERY DATA							DAYS OUT	DISTANCE (Km)	RATE (Km DAY)	LOCATION OF WORK	
			BOTTLE NO.	BALLAST	DATE			LATITUDE		LONGITUDE		DATE			LATITUDE		LONGITUDE						
					YR	MO.	DA.	DEG	MIN	DEG	MIN	YR	MO.	DA.	DEG	MIN	DEG	MIN					
1 2	3	4 5 6 7	8 9 10 11 12	13	14 15	16 17	18 19	20 21	22 23 24 25	26 27	28 29 30 31	32 33	34 35	36 37	38 39	40 41 42 43	44 45	46 47 48 49	50 51 52	53 54 55 56 57 58	59 60 61 62		
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DRIFT BOTTLE RELEASE/RECOVERY LOG

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	"50" (constant)
Card Type	3	1	I1	"1" (constant)
Cruise Number	4	4	I4	Cruise Number
Bottle Number	8	5	I4	Bottle Number
Ballast	13	1	A1	Ballast
RELEASE DATA				
Date	14	6	3I2	Year, month and day of release
Latitude	20	6	I2, F4.1	Latitude of release in degrees and minutes to tenths of a minute
Longitude	26	6	I2, F4.1	Longitude of release in degrees and minutes to tenths of a minute
RECOVERY DATA				
Date	32	6	3I2	Year, number and day of recovery
Latitude	38	6	I2, F4.1	Latitude of recovery in degrees and minutes to tenths of a minute
Longitude	44	6	I2, F4.1	Longitude of recovery in degrees and minutes to tenths of a minute
Day Out	50	3	I3	Number of days out
Distance	53	6	F6.1	Distance traveled in kilometers to tenths
Rate	59	4	F4.1	Rate in kilometers/day to tenths
Location	63	5	3A, A2	Location of work Col 63 = N = North 64 = W = West 65 = G = Gulf 66, 67 = MX = Mexico

DYE STUDY

FILE TYPE	RECORD TYPE	EXPERIMENT	DATE OF RELEASE			TIME OF RELEASE	PLATFORM	POSITION TO CENTER OF DYE PATCH		BOTTOM DEPTH (M)	VESSEL	REMARKS
			MO	DAY	YR			DISTANCE FROM PLATFORM (KM)	BEARING FROM PLATFORM (MAG)			
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20	21 22 23 24	25 26 27	28 29 30	31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54	55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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FILE TYPE	RECORD TYPE	EXPERIMENT	DATE			TIME	PLATFORM	POSITION TO CENTER OF DYE PATCH		DYE PATCH DIMENSIONS						REMARKS
										MAJOR AXIS		MINOR AXIS				
			MO	DAY	YR			DISTANCE FROM PLATFORM (KM)	BEARING FROM PLATFORM (MAG)	LENGTH (M)	AXIS ORIENTATION (MAG)	WIDTH (M)	AXIS ORIENTATION (MAG)	AREA $(10^3 M^2)$	DEPTH PENETRATION (M)	
1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20	21 22 23 24	25 26 27	28 29 30 31	32 33 34 35 36 37	38 39 40 41	42 43 44 45 46 47	48 49 50 51 52 53	54 55 56 57	58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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1 2	3	4 5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20	21 22 23 24	25 26 27	28 29 30 31	32 33 34 35 36 37	38 39 40 41	42 43 44 45 46 47	48 49 50 51 52 53	54 55 56 57	58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NPEL 111

DYE STUDY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type-"40"-constant
Record Type	3	1	I1	Record type-"1"-constant
Experiment	4	6	A6	Experiment
Date of Release	10	6	3I2	Month, day and last two digits of year
Time of Release	16	4	I4	Time - 24-hour clock
Platform	20	1	A1	Platform of release A= Platform A B= Platform B
Distance from Platform	21	4	F4.1	Distance from platform in km to tenths to center of dye patch (decimal included)
Bearing from Platform	25	3	I3	Bearing from platform (magnetic) to center of dye patch
Bottom Depth	28	3	I3	Bottom depth in meters
Vessel	31	24	4A6	Vessel name

DYE STUDY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type-"40"-constant
Record Type	3	1	I1	Record type-"2"-constant
Experiment	4	6	A6	Experiment
Date	10	6	3I2	Month, day and last two digits of year
Time	16	4	I4	Time - 24-hour clock
Platform	20	1	A1	Platform A = Platform A B = Platform B
Distance From Platform	21	4	F4.1	Distance from platform in km to tenths to center of dye patch (decimal included)
Bearing From Platform	25	3	I3	Bearing from platform (magnetic) to center of dye patch
Major Axis Length	28	4	I4	Length of major axis in meters
Major Axis Orientation	32	6	2I3	Axis orientation (magnetic)
Minor Axis Width	38	4	I4	Width of minor axis in meters
Minor Axis Orientation	42	6	2I3	Axis orentation (magnetic)
Area	48	6	F6.1	Area in $10^3 m^2$ (decimal included)
Penetration	54	4	F4.1	Depth of penetration in meters to tenths (decimal included)

TRANSPONDING BUOY

FILE TYPE	RECORD TYPE	CRUISE	BUOY NUMBER	DATE OF RELEASE			TIME	LATITUDE		LONGITUDE		CURRENT DEPTH (M)	VESSEL	RESULTANT DRIFT DIRECTION	RESULTANT DRIFT SPEED	
				MO	DAY	YR		DEG	MIN	DEG	MIN					
1 2	3	4 5 6 7 8 9	10 11 12 13	14 15	16 17	18 19	20 21 22 23	24 25	26 27 28 29	30 31	32 33 34 35	36 37 38 39	40 … 69	70 71 72	73 74 75 76	77 78 79 80
4 1	1								●		●	●			●	

FILE TYPE	RECORD TYPE	CRUISE	BUOY NUMBER	DAYS AFTER RELEASE	DATE			TIME	LATITUDE		LONGITUDE		DIRECTION (MAG)	DISTANCE (N. M.)	SPEED (KNOTS)	REMARKS
					MO	DAY	YR		DEG	MIN	DEG	MIN				
1 2	3	4 5 6 7 8 9	10 11 12 13	14 15	16 17	18 19	20 21	22 23 24 25	26 27	28 29 30 31	32 33	34 35 36 37	38 39 40	41 42 43 44	45 46 47 48	49 … 80
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
4 1	2									●		●		●	●	
1 2	3	4 5 6 7 8 9	10 11 12 13	14 15	16 17	18 19	20 21	22 23 24 25	26 27	28 29 30 31	32 33	34 35 36 37	38 39 40	41 42 43 44	45 46 47 48	49 … 80

NFEL 112

TRANSPONDING BUOY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type-"41"-constant
Record Type	3	1	I1	Record type-"1"-constant
Cruise	4	6	A6	Cruise number
Buoy Number	10	4	I4	Buoy number
Release Date	14	6	3I2	Month, day and last two digits of year of release
Time	20	4	I4	Time (24-hour clock)
Station	24	6	A6	Station number
Latitude	30	6	F6.1	Latitude of release to tenth of a minute (decimal included)
Longitude	36	6	F6.1	Longitude of release to tenth of a minute (decimal included)
Current Depth	42	4	F4.1	Depth of current measured in meters to tenths (decimal included)
Vessel	46	24	4A6	Vessel name
Resultant Drift Direction	70	3	I3	Direction of resultant drift (magnetic)
Resultant Drift Speed	73	4	F4.1	Speed of resultant drift - n.m./day (decimal included)

TRANSPONDING BUOY

Field Name	Position	Length	Format	Use and Meaning
File Type	1	2	I2	File type-"41"-constant
Record Type	3	1	I1	Record type-"2"-constant
Cruise	4	6	A6	Cruise number
Buoy Number	10	4	I4	Buoy number
Days After Release	14	2	I2	Days after release
Date	16	6	3I2	Month, day and last two digits of year
Time	22	4	I4	Time (24-hour clock)
Latitude	26	6	F6.1	Latitude to tenth of a minute (decimal included)
Longitude	32	6	F6.1	Longitude to tenth of a minute (decimal included)
Direction	38	3	I3	Direction of movement (magnetic)
Distance	41	4	F4.1	Distance of movement in nautical miles to tenths (decimal included)
Speed	45	4	F4.1	Speed in knots to tenths (decimal included)

TASK 2.4.1

NON-METAL ANALYSIS

HYDROCARBONS

SOURCE	CODE	CARD TYPE	DATA SET	SAMPLE DATE			LATITUDE			LONGITUDE			SITE	SOURCE	COMMENTS
				MO	DAY	YR	DEG.	MIN.		DEG.	MIN.				
1	2	3	4 5 6 7 8	9 10	11 12	13 14	15 16	17 18 19 20	21	22 23	24 25 26 27	28	29 30 31 32 33 34 35 36 37 38	39 40 41 42 43 44 45 46 47 48 49 50	51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
6	2	1													

SOURCE	CODE	CARD TYPE	DATA SET	ANALYSIS DATE			ANALYST	EXAMINATION TYPE	AMOUNT ANALYZED (GRAMS)	COMMENTS
				MO	DAY	YR				
1	2	3	4 5 6 7 8	9 10	11 12	13 14	15 16 17 18 19 20 21 22 23 24 25 26	27 28	29 30 31 32 33 34 35 36	37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
6	7	2								

SOURCE	CODE	CARD TYPE	DATA SET	COMPOUND	CONCENTRATION	UNIT	COMMENTS
1	2	3	4 5 6 7 8	9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	49 50 51 52 53 54	55	56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
6	2	3					
6	2	3					
6	2	3					
6	2	3					
6	2	3					
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6	2	3					
6	2	3					
1	2	3	4 5 6 7 8	9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	49 50 51 52 53 54	55	56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

HYDROCARBONS

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"62" (Constant)
Card Type	3	1	I1	"1" (Constant)
Data Set	4	5	A5	Data set code number. First digit is last digit of sample year, i.e., 19th sample of 1976 is 60019.
Sample Date	9	6	3I2	Month, day, year of sample
Latitude	15	6	I2, F4.2	Latitude in Deg. and Min. to hundreths
Longitude	22	6	I2, F4.2	Longitude in Deg. and Min. to hundreths
Site	29	10	A6, A4	Collection Site (GCFC notation)
Source	39	12	2A6	Name of agency or person from whom sample was obtained
Description	51	30	5A6	Sample description

HYDROCARBONS

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"62" (Constant)
Card Type	3	1	I1	"2" (Constant)
Data Set	4	5	A5	Data set code number. (Must agree with card 1)
Analysis Date	9	6	3I2	Month, day, year of analysis
Analyst	15	12	2A6	Name of Analyst
Examination Type	27	2	A2	GC = sample examined by gas chromatography MS = sample examined by mass spectrometry
Amount Analyzed	29	8	F8.4	Amount of sample analyzed in grams
Comments	37	43	7A6, A1	Comments on Analysis

HYDROCARBONS

Field Name	Position	Length	Format	Use and Meaning
Data Source Code	1	2	I2	"62" (Constant)
Card Type	3	1	I1	"3" (Constant)
Data Set	4	5	A5	Data set code number. (Must agree with card 1 and card 2
Compound	9	40	6A6, A4	Compound name or abbreviation (i.e., NC20 = n-eicosane, the n-alkane with 20 carbon atoms per molecule)
Concentration	49	6	A6.0	Compound concentration (number or the word TRACE. The decimal, if any, should be included in number).
Unit	55	1	A1	C = percent M = parts per million B = parts per billion T = parts per trillion
Comment	56	24	4A6	Comments on individual compounds

TASK 2.4.2

TRACE METALS

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

FILE TYPE	RECORD TYPE	STATION NUMBER	DATE			SAMPLE TIME (24 HOUR CLOCK)	LATITUDE				LONGITUDE				NAVIGATION CODE	SAMPLE DEPTH (M)	BOTTOM DEPTH (M)	SECCHI (M)	BAROMETRIC PRESSURE (MB)	DRY BULB (°C)	WET BULB (°C)	WATER TEMPERATURE (°C)	
			MO	DAY	YR		DEG	MIN	SEC	N or S	DEG	MIN	SEC	E or W									
1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23	24 25	26	27 28 29	30 31	32 33	34	35 36	37 38 39 40 41 42	43 44 45 46 47 48	49 50 51 52 53	54 55 56 57 58	59 60 61 62	63 64 65 66	67 68 69 70	71 72 73 74 75 76 77 78 79 80
0 0 1	1															.	.	.	.	.	.	.	
0 0 1	1															.	.	.	.	.	.	.	
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1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23	24 25	26	27 28 29	30 31	32 33	34	35 36	37 38 39 40 41 42	43 44 45 46 47 48	49 50 51 52 53	54 55 56 57 58	59 60 61 62	63 64 65 66	67 68 69 70	71 72 73 74 75 76 77 78 79 80

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

FILE TYPE	RECORD TYPE	STATION NUMBER	DATE			SAMPLE TIME (24 HOUR CLOCK)	SEQUENCE NUMBER	SPECIES	SEX	MATERIAL ANALYZED	COUNT	LENGTH (MM)	WEIGHT(GR)	SAMPLE STATE	PERCENT DRY	DRYING TEMP (°C)	PERCENT DRY	DRYING TEMP (°C)
			MO	DAY	YR													
1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	46	47 48	49 50 51	52 53 54 55 56	57 58 59 60 61 62	63 64	65 66 67 68	69 70 71 72	73 74 75 76	77 78 79 80
0 0 1	2																	
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1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45	46	47 48	49 50 51	52 53 54 55 56	57 58 59 60 61 62	63 64	65 66 67 68	69 70 71 72	73 74 75 76	77 78 79 80

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

FILE TYPE	RECORD TYPE	STATION NUMBER	DATE			SAMPLE TIME (24 HOUR CLOCK)	SEQUENCE NUMBER	SPECIES	ELEMENT ANALYZED	METHOD OF ANALYSIS	DATE OF ANALYSIS			CONCENTRATION			
			MO	DAY	YR						MO	DAY	YR	REPLICATE 1	REPLICATE 2	REPLICATE 3	REPLICATE 4
1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44	45 46	47 48 49 50	51 52	53 54	55 56	57 58 59 60 61 62	63 64 65 66 67 68	69 70 71 72 73 74	75 76 77 78 79 80
0 0 1	3																
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1 2 3	4	5 6 7 8 9	10 11	12 13	14 15	16 17 18 19	20 21	22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44	45 46	47 48 49 50	51 52	53 54	55 56	57 58 59 60 61 62	63 64 65 66 67 68	69 70 71 72 73 74	75 76 77 78 79 80

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

Field Name	Position	Length	Format	Use and Meaning
File Type	1	3	I3	"001" (constant)
Record Type	4	1	I1	"1" (constant)
Station	5	5	A5	Station Number
Date	10	6	3I2	Month, day, and year of sample
Time	16	4	I4	Time of sample (24 Hour Clock))
Latitude	20	6	3I2	Degrees, minutes, seconds
Lathem	26	1	A1	Hemisphere "N" or "S"
Longitude	27	7	I3, 2I2	Degrees, minutes, seconds
Lonhem	34	1	A1	Hemisphere "E" or "W"
Navigation	35	2	I2	(see attached codes)
Sample Depth	37	6	F6.1	Sample depth to tenths of a meter
Bottom Depth	43	6	F6.1	Water depth to tenths of a meter
Secchi	49	5	F5.1	Secchi Disk Depth; to tenths of a meter
Barometric Pressure	54	5	F5.2	Barometric pressure to hundreth of a millibar
Dry Bulb	59	4	F4.1	Air temperature to tenths of degrees celsius
Wet Bulb	63	4	F4.1	Air temperature to tenths of degrees celsius
Water Temperature	67	4	F4.1	Water temperature to tenths of degrees celsius
File Type	1	3	I3	"001" (constant)
Record Type	4	1	I1	"2" (constant)
Station	5	5	A5	Station Number
Date	10	6	3I2	Month, day, and year of sample
Time	16	4	I4	Time of sample (24 Hour Clock)
Sequence	20	2	I2	Sequence Number of type 2 cards for this station
Species	22	24	4A6	Species name or code for sediment (S) or code for water (W)

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

Field Name	Position	Length	Format	Use and Meaning
Sex	46	1	A1	M = Male F = Female blank = both sexes used, unknown or not applicable
Count	47	3	I3	Number of animals in sample
Material Analyzed	50	2	I2	(See attached code)
Length	52	5	I5	Average length of specimens to whole millimeters
Weight	57	6	I6	Average weight of specimens to whole grains
Sample State	63	2	I2	(See attached codes)
Percent Dry	65	4	F4.2	Dry weight percent of wet weight to hundreths. Initial determination
Drying Temperature	69	4	F4.2	Initial determination; °C to nearest degree
Percent Dry	73	4	I4	Dry weight percent of wet weight to hundredths. Determination at analysis
Drying Temperature	77	4	I4	At analysis, °C to nearest degree
File Type	1	3	I3	"001" (constant)
Record Type	4	1	I1	"3" (constant)
Station	5	5	A5	Station Number
Date	10	6	3I2	Month, day and year of sample
Time	16	4	I4	Time of sample (24 Hour Clock)
Sequence	20	2	I2	Sequence Number of type 3 cards for this station
Species	22	24	4A6	Species name or code for sediment (S) or code for water (W)
Element Analyzed	46	2	A2	Standard element abbreviation
Method of Analysis	48	3	A3	(See attached code)
Date of Analysis	54	6	3I2	Month, day, year of analysis

TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER

Field Name	Position	Length	Format	Use and Meaning
Concentration				
Replicate 1	57	6	2I3	Expressed in parts per million (ppm) in scientific notation to three significant digits, i.e., 1.11 ppm = 111 + 00 0.111 ppm = 111 - 01 11.1 ppm = 111 + 01
Replicate 2	63	6	2I3	
Replicate 3	69	6	2I3	
Replicate 4	75	6	2I3	

SPECIAL CODES
TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER FILE (type "100")

NAVIGATION CODE

01 = Loran (mixed or unspecified)
02 = Radar and/or fixes
03 = Raydist without complications
04 - Raydist with errors, drifting, etc.
05 = Satellite
06 = Omega
07 = Loran A only
08 - Loran B only
09 = Loran C only

MATERIAL ANALYZED CODE

01 = Muscle
02 = Liver
03 = Digestive gland
04 = Gonad
05 = Gills
06 = Kidney
07 = Spleen
08 = Heart
09 = Brain
10 = Blood
11 = Stomach contents
12 - Tom 1 1/2" of sediment core
13 = Middle 1 1/2" of sediment core
14 = Remainder of sediment core
15 = Whole organism
16 = Water
17 = Particulate matter

SAMPLE STATE CODE

01 = Fresh frozen
02 = Freeze dried
03 = Oven dried at 105-115°C
04 = Formaldehyde preserved
05 = Oven dried at 60°C
06 = Fresh, preserved at 33-40°F
07 = Raw
08 = Cooked
09 = Canned

SPECIAL CODES
TRACE METALS IN ORGANISMS, SEDIMENT, AND WATER FILE (type "100")

METHOD OF ANALYSIS

W = Data expressed on wet weight basis
D = Data expressed on dry weight basis

followed by:

01 = Milford dry ashing method
02 = Repetitive wet ash method using 30 ml. HNO_3
03 = Mercury analysis - flameless AA
04 = Standard sediment method - 50% HNO_3 extraction
05 = Kosiesza - Anal. Services, Inc., arsenic method
06 = Kosiesza - Anal. Services, Inc., Cd, Cr, Pb method
07 = Nondestructive neutron activation
08 = Milford arsenic method
09 = Mercury in sediment, EPA aqua regia method
10 = Wet ash, concentrated HNO_3 method from "Marine Pollution Monitoring; Strategies for a National Policy." Edited by Dr. Edward Goldberg, Scripps Institution of Oceanography

APPENDIX 3

DATA VERIFICATION REPORTS

```
                                 *SEDIMENT DATA*


***************************STATION***************************
NUMBER          NAME                          TYPE                    LATITUDE    LONGITUDE     DATE
 S102     STATION 102                   FIELD STATION                 28 55.05    94 39.25    06/11/76

                                       PERCENT OF SAMPLE IN SEDIMENT RANGE (PHI)

(-1.0 -.75) (-.75 -.50) (-.50 -.25) (-.25 0.0) (0.0 .25) (.25 .50) (.50 .75) (.75 1.0) (1.0 1.25) (1.25 1.50) (1.5 1.75)
    1.75        0.26        0.35        0.33       0.19      0.20      0.12      0.15      0.10        0.07         0.08

(1.75 2.00) (2.00 2.25) (2.25 2.50) (2.50 2.75) (2.75 3.00) (3.00 3.25) (3.25 3.50) (3.50 3.75) (3.75 4.00) (4.00 4.25)
    0.11        0.17        0.14        0.23        1.56        1.84        3.69        4.63        3.72        1.64


   PERCENT OF SAMPLE                              PERCENT OF SAMPLE WEIGHT
SAND     SILT     CLAY               HEAVY      *********CLAY MINERALOGY*********
21.27    37.54    41.19             MINERALS     EXPANDABLES   ILLITE    KAOLINITE
                                                    68.00       20.00      12.00
```

```
                                                          SHRIMP BIOASSAY

     EXPERIMENT EPA003  SEGMENT 19     SEPTEMBEP **,1977     PENAEUS SETIFERUS        -LA GF       5 CONTAINERS

      ***************                                     SAMPLE                                    ***************
         DATE    TIME      SOURCE      SALINITY  TEMPERATURE  CONDITION  VOLUME  CONCENTRATION
                                         (PPT)       (C)                  (ML)       (PPM)
       8/21/77  1000  PLATFOM B          35.5                  YELLOW

          ******  CONTAINER  1    ***** ******  CONTAINER  2    ***** ******  CONTAINER  3    ***** ******  CONTAINER  4    *****
DATE TIME OK  DEAD MORIBUND STRESS MOLT OK  DEAD MORIBUND STRESS MOLT OK  DEAD MORIBUND STRESS MOLT OK  DEAD MORIBUND STRESS MOLT
9/ 2 1130  2                             2                             2                             2
9/ 2 1330  2                             2                             2                             2
9/ 2 1600  2                             2                             2                             2
9/ 2 2330  2                             2                             2                             1    1
9/ 3  800  1    1                        1    1                        1    1                             1
9/ 3 1130  1                             1                             1
9/ 4  800       1                             1                                            1
9/ 5  800                                                              1
9/ 6  800                                                              1
          ******  CONTAINER  5    *****
DATE TIME OK  DEAD MORIBUND STRESS MOLT
9/ 2 1130  2
9/ 2 1330  2
9/ 2 1600  2
9/ 2 2330  2
9/ 3  800  1    1
9/ 3 1130                      1
9/ 4  800       1                    1
9/ 5  800
9/ 6  800
```

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```
                                                  DEMERSAL FISH

                                                                                      TOTAL               NUMBER OF
                                         START            SAMPLE               VESSEL  NUMBER     TOTAL    DIFFERENT   SUBSAMPLE
   DATE    STATION LATITUDE LONGITUDE TIME  DURATION DEPTH     GEAR TYPE     SPEED   CAUGHT    WEIGHT    SPECIES       WEIGHT
                                            HR/MIN   (M)                     (KT)               (KG)                    (KG)
 10/18/77      AS    285330    944142   1922      5    21.3  TRAWLING          .3       27   3710.9          7         3710.9


                                  NUMBER IN    SPECIES
                        SPECIES    SAMPLE      WEIGHT SCIENTIFIC NAME
                                                (GMS)
                      141220101      20        3415.3 ARIUS FELIS

                          *MEASURED INDIVIDUALS*
                          SAMPLE  LENGTH  WEIGHT   SEX
                          NUMBER   (MM)   (GMS)
                             1      219    138.3  MALE
                             2      264    290.1  FEMALE
                             3      231    160.8  MALE
                             4      261    254.4  FEMALF
                             5      230    173.5  FEMALE
                             6      290    345.8  FEMALE
                             7      269    266.0  MALE
                             8      202    179.8  FEMALE
                             9      207    123.2  MALE
                            10      177     66.6  FEMALE
                            11      217    140.4  MALE
                            12      236    194.0  FEMALE
                            13      229    173.8  FEMALE
                            14      215    144.6  FEMALE
                            15      176     57.9  MALE
                            16      207    113.9  FEMALE
                            17      243    215.9  MALE
                            18      232    156.3  MALE
                            19      215    139.3  FEMALE


                                  NUMBER IN    SPECIES
                        SPECIES    SAMPLE      WEIGHT SCIENTIFIC NAME
                                                (GMS)
                      170151107       2         156.3 LUTJANUS CAMPECHANUS

                          *MEASURED INDIVIDUALS*
                          SAMPLE  LENGTH  WEIGHT   SEX
                          NUMBER   (MM)   (GMS)
                             1      19[illegible]    146.3  MALE
                             2      7[illegible]     [illegible]  MALE
```

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                                              REEF FISH

                                                                          TOTAL              NUMBER OF
                                    START            SAMPLE                      VESSEL  NUMBER    TOTAL   DIFFERENT   SUBSAMPLE
  DATE    STATION LATITUDE LONGITUDE TIME  DURATION DEPTH     GEAR TYPE    SPEED  CAUGHT   WEIGHT   SPECIES       WEIGHT
                                           HR/MIN    (M)                    (KT)             (GMS)                  (GMS)
2/28/78    801    285216    944149    0              2.3  AIR-LIFT                  10    30.40        2            .00


                                    NUMBER IN     SPECIES
                        SPECIES       SAMPLE      WEIGHT SCIENTIFIC NAME
                                                   (GMS)
                       170360701        9         268.06 HYPLEUROCHILUS GEMINATUS

                          *MEASURED INDIVIDUALS*
                          SAMPLE  LENGTH  WEIGHT  SEX
                          NUMBER   (MM)    (GMS)
                             1       57     3.10  MALE
                             2       59     3.41  MALE
                             3       55     2.97  MALE
                             4       43     1.20  FEMALE
                             5       43     1.51  MALE
                             6       40     1.18  FEMALE
                             7       56     2.75  MALE
                             8       57     1.60  MALE
                             9       81     9.16  MALE


                                    NUMBER IN     SPECIES
                        SPECIES       SAMPLE      WEIGHT SCIENTIFIC NAME
                                                   (GMS)
                       170360301        1         35.02 BLENNIUS MARMOREUS

                          *MEASURED INDIVIDUALS*
                          SAMPLE  LENGTH  WEIGHT  SEX
                          NUMBER   (MM)    (GMS)
                             1       69     3.52  MALE
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                                        *REEF FISH CENSUS*

*EXPERIMENT NUMBER* SUMMER    *LOCATION*     PLATFORM A PRODUCTION     *AREA(SQ.M)* 1.0   *LIMITS:(UPPER) 5 FT    (LOWER)10 FT*

      *STATION* 1E               DATE        TIME     BIONUMERIC CODE      NUMBER      DIVER          COMMON NAME
                               8/11/77       1037       8000000004           79          1            BLENNY
                                                                             70          2
                                                                             45          3
                               8/11/77       1037       1700042603            6          1            BELTED SANDFISH
                                                                              6          2
                                                                              1          3
                               8/11/77       1037       1702270504            2          1            COCOA DAMSELFISH
                                                                              4          2
                                                                              1          3
                               8/11/77       1037       1702130601            4          1            SHEEPSHEAD
                                                                              1          2
                                                                              1          3
                               8/11/77       1037       2291000702            6          1            STONE CRAB
                                                                             11          2
                                                                             40          3
```

PELAGIC FISH CENSUS

LOCATION PLATFORM A PRODUCTION EXPERIMENT NUMBER SLAYES STATION NUMBER 6

DATE	TIME	DEPTH (FT)	VOLUME M**3	BIONUMERIC CODE	NUMBER OF SPECIES	COMMON NAME
09/21/77	102	40	107	NO FISH		
09/21/77	1027	40	107	NO FISH		
09/21/77	1034	40	107	999999999	1	
09/21/77	1041	40	107	999999999	1	
09/21/77	104	40	107	NO FISH		
09/21/77	1055	40	107	NO FISH		
09/21/77	1102	40	82	NO FISH		
09/21/77	1109	40	107	NO FISH		
09/21/77	111	40	107	999999999	2	
09/21/77	112	40	107	NO FISH		
09/21/77	112	40	107	NO FISH		
09/21/77	1136	40	82	NO FISH		
09/21/77	1143	40	107	170250101	3	ATLANTIC SPADEFISH
09/21/77	115	40	82	999999999	1	
09/21/77	115	40	82	NO FISH		
09/21/77	1204	40	107	170250101	3	ATALNTIC SPADEFISH
09/21/77	1211	40	82	999999999	1	
09/21/77	121	40	107	170250101	2	ATLANTIC SPADEFISH
09/21/77	121	40	107	999999999	1	
09/21/77	122	40	107	NO FISH		
09/21/77	123	40	107	999999999	2	
09/21/77	1239	40	107	NO FISH		
09/21/77	1246	40	82	NO FISH		
09/21/77	1259	40	107	NO FISH		
09/21/77	130	40	82	NO FISH		
09/21/77	1313	40	107	NO FISH		
09/21/77	132	40	107	NO FISH		
09/21/77	1327	40	82	NO FISH		
09/21/77	1334	40	82	NO FISH		
09/21/77	1341	40	82	NO FISH		

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                         *BRINE DYE RELEASE*

*LOCATION*     PLATFORM A PRODUCTION          *EXPERIMENT NUMBER* SUMMER*TYPE* GREATEST CONCENTRATION

*DATE*  8/17/77                                       *GENERAL DIRECTION OF WATER MOVEMENT*

LEG            1    2    3    4    5    6    7    8    9   10   11   12
DEPTH(FT)      ***************************************************************
*TIME* 1330    0    2    0    0   25   25   25    0    0   30   30   25        NORTH
*TIME* 1530    0    2    0    0   25   20    0    0    0    0   20   10        NORTH
*TIME* 1730    0   15    0    0    0   30   20    0    0    0   12   12        NORTH
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                                        *FISH BIOASSAY*

  *EXPERIMENT*      *START*      * END  *         *CONTROL AREA*                 *BRINE AREA*

     WINTER         2/23/78      2/25/78    WELL JACKET I                   PLATFORM B PRODUCTION

                *FIRST SPECIES*                               *SECOND SPECIES*
  BIOCODE        CONTROL         BRINE          BIOCODE       CONTROL       BRINE                CONTROL MISSING 5
               ALIVE DEAD     ALIVE DEAD                    ALIVE DEAD    ALIVE DEAD             BRINE   MISSING 1
 170360701       19    3        16    3         170360301     12     0       0    20

              ELAPSED
     DATE       TIME      AREA     CONDITION      BIOCODE       LENGTH(MM)   WEIGHT(GR)    SEX       COMMON NAME
    2/24/78     2315      BRINE      DEAD        170360301          79         4.500       MALE      SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          72         3.290       MALE      SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          75         3.300       MALE      SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          70         2.900       MALE      SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          59         2.050       MALE      SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          59         1.900      FEMALE     SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          57         1.890      FEMALE     SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          55         1.450      FEMALE     SEAWEED BLENNY
    2/24/78     2315      BRINE      DEAD        170360301          52         1.080      FEMALE     SEAWEED BLENNY
    2/24/78     2815      BRINE      DEAD        170360301          84         5.180       MALE      SEAWEED BLENNY
    2/24/78     2815      BRINE      DEAD        170360301          73         3.260       MALE      SEAWEED BLENNY
    2/24/78     2815      BRINE      DEAD        170360301          69         2.820       MALE      SEAWEED BLENNY
    2/24/78     2815      BRINE      DEAD        170360701          66         2.200       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      DEAD        170360701          65         3.290       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      DEAD        170360701          59         2.010       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          79         4.720       MALE      SEAWEED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          77         4.130       MALE      SEAWEED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          65         2.770       MALE      SEAWEED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          67         2.620       MALE      SEAWEED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          70         3.650      FEMALE     SEAWEED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          63         2.420      FEMALE     SEAWEED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          61         2.140      FEMALE     SEAWEED BLENNY
    2/25/78     4715      BRINE      DEAD        170360301          55         1.520      FEMALE     SEAWEED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          80         6.910       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          74         5.300       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          69         4.560       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          59         2.050       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          55         2.460       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          57         2.360       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          53         2.000       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          48         1.600       MALE      CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          56         1.880      FEMALE     CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          52         1.800      FEMALE     CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          46         1.100      FEMALE     CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          46         1.400      FEMALE     CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          41          .840      FEMALE     CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          38          .680      FEMALE     CRESTED BLENNY
    2/25/78     4715      BRINE      ALIVE       170360701          59         2.590      FEMALE     CRESTED BLENNY
    2/25/78     4430     CONTROL     DEAD        170360701          67         2.000       MALE      CRESTED BLENNY
    2/25/78     4430     CONTROL     DEAD        170360701          74         2.830       MALE      CRESTED BLENNY
    2/25/78     4430     CONTROL     DEAD        170360701          77         2.820       MALE      CRESTED BLENNY
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STOMACH CONTENTS

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             STATION                                     DEPTH                       BIONUMERIC    NUMBER
   DATE       NUMBER   LATITUDE   LONGITUDE   TIME    (M)        GEAR TYPE         CODE       EXAMINED

  8/17/77        A       28.89       94.69      900    21.3   BOTTOM TRAP      170211601        1
           BIONUMERIC
 SAMPLE        CODE      LENGTH    WEIGHT     SEX          SCIENTIFIC NAME
                          (MM)    (GRAMS)
    1      170211601      122      37.8    ******  ******LAGODON RHOMBOIDES
  ***

                                 STOMACH     CONTENTS    NUMBER
                                 CONTENTS     WEIGHT     PRESENT
                                             (GRAMS)
                              1  12003                    9999
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                                                   ICHTHYOPLANKTON

CRUISE  *** COLLECTION GEAR ***     DATE       LATITUDE      LONGITUDE      START                DISPLACEMENT    WATER    NUMBER
                                             DEG MIN SEC   DEG MIN SEC      TIME   DURATION        VOLUME      FILTERED  OF EGGS
                                                                                   MIN. SEC         (ML)
  1     NEUSTON NET                7/14/77   28  53  29    94  41  27      1809    10   0          14.1                     22

                                      SPECIES       NUMBER        MIN.    MAX.    MEAN
                                                      OF          SIZE    SIZE    SIZE
                                                   SPECIMINS      (ML)    (ML)    (ML)
                                     147010000          1          5.9     5.9     5.9
                                     170110902          1          6.1     6.1     6.1
                                     147040000         41          7.3     8.8     7.8
                                     147040700          1         11.3    11.3    11.3
                                     147041001          1         11.1    11.1    11.1
                                     170201800          1          6.2     6.2     6.2
                                     199080600          6          6.0     7.5     6.5
                                     UNKNOWN            5           .0      .0      .0
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                         BACTERIA-BEHAVIOR
                             TOXICITY

                                                 % BRINE    % BUCCANEER
                                         STRAIN DISCHARGE   CONDENSATE   BACTRON
DATE      INOCULUM    CRUISE STATION  SOURCE  CODE    ADDED        ADDED       ADDED

9/19/77 MIXED CULTURE   1       6      TOP             10                       10

                            DIFFERENCE
                               FROM
                     TIME  ORIGINAL TVC
                             COUNT/EXP

                       0  -  1.00 00
                       4  +  1.00 00
                       8      .00 00
                      24  +  5.90 01
                      48  +  8.48 02
```

BACTERIA-BEHAVIOR
CHEMOTAXIC

DATE	CRUISE	STATION	SOURCE	STRAIN CODE	PERCENT ARGININE ADDED	PERCENT DH2C ADDED	PERCENT GLUCOSE ADDED	PERCENT BUCCANEER CRUDE ADDED	PERCENT BUCCANEER DISCHARGE ADDED	TIME (MIN)	DIFFERENCE FROM ORIGINAL TVC COUNT/EXP
8/30/77				SEC			6			60	+ 1.00 02
8/30/77				SEC			6		1	60	- 2.93 04
8/30/77				SEC	6					60	+ 3.00 04
8/30/77				SEC	6				1	60	- 2.61 04
8/30/77	1	4	SEDIMENT	091			6			60	- 2.30 01
8/30/77	1	4	SEDIMENT	091			6		1	60	- 1.16 02
8/30/77	1	4	SEDIMENT	091	6					60	- 4.70 01
8/30/77	1	4	SEDIMENT	091	6				1	60	- 1.12 02
11/22/77				SEC			6			60	+ 1.00 00
11/22/77				SEC	6					60	+ 1.00 00
11/22/77	1	1	SEDIMENT	013			6			60	- 7.50 00
11/22/77	1	1	SEDIMENT	013	6					60	- 2.90 01
11/22/77	1	5	BOTTOM	051			6			60	+ 7.70 01
11/22/77	1	5	BOTTOM	051	6					60	+ 2.20 01
11/26/77				SEC					1	90	+ 9.00 00
11/26/77				SEC				6		90	+ 6.80 01
11/26/77				SEC				6	1	90	+ 4.20 01
11/26/77				SEC			6			90	+ 1.20 01
11/26/77				SEC			6		1	90	+ 6.00 00
11/26/77				SEC	6					90	.00 00
11/26/77				SEC	6				1	90	+ 1.00 00
11/26/77	1	1	SEDIMENT	009					1	90	- 2.50 01
11/26/77	1	1	SEDIMENT	009				6		90	- 3.00 00
11/26/77	1	1	SEDIMENT	009				6	1	90	+ 2.30 01
11/26/77	1	1	SEDIMENT	009			6			90	- 6.00 00
11/26/77	1	1	SEDIMENT	009			6		1	90	+ 3.90 01
11/26/77	1	1	SEDIMENT	009	6					90	- 6.00 00
11/26/77	1	1	SEDIMENT	009	6				1	90	- 6.00 00
11/26/77	1	5	SEDIMENT	060					1	90	+ 4.30 01
11/26/77	1	5	SEDIMENT	060				6		90	+ 6.80 01
11/26/77	1	5	SEDIMENT	060				6	1	90	+ 3.80 01
11/26/77	1	5	SEDIMENT	060			6			90	+ 3.30 01
11/26/77	1	5	SEDIMENT	060			6		1	90	+ 7.20 01
11/26/77	1	5	SEDIMENT	060	6					90	+ 5.40 01
11/26/77	1	5	SEDIMENT	060	6				1	90	+ 2.30 01
12/20/77				SEC					1	90	+ 1.70 01
12/20/77				SEC				6		90	+ 1.00 00
12/20/77				SEC				6	1	90	+ 4.00 01
12/20/77				SEC			6			90	- 2.70 01
12/20/77				SEC			6		1	90	+ 4.00 00
12/20/77				SEC	6					90	- 2.50 01
12/20/77				SEC	6				1	90	+ 3.10 01

BACTERIA-BEHAVIOR
ATTACHMENT STUDIES

DATE	INOCOLUM	CRUISE	STATION	SOURCE	PERCENT BUCCANEER DISCHARGE ADDED	BACTRON ADDED	DIFFERENCE FROM ORIGINAL TVC COUNT/EXP
9/22/77	PURE CULTURE	1	4	SEDIMENT		NO	+ 1.39 05
9/22/77	PURE CULTURE	1	4	SEDIMENT		YES	+ 2.48 05
9/22/77	PURE CULTURE	1	5	MIDDLE		NO	+ 2.91 06
9/22/77	PURE CULTURE	1	5	MIDDLE		YES	+ 1.31 06
9/22/77	MIXED CULTURE	1	6	TOP		NO	- 1.46 06
9/22/77	MIXED CULTURE	1	6	TOP		YES	- 1.58 06
9/22/77	PURE CULTURE					NO	+ 8.00 01
9/22/77	PURE CULTURE					YES	+ 8.00 01

BACTERIA DEGRADATION RATES

DATE	INOCULUM	CRUISE	STATION	SOURCE	STRAIN	*REACTION MIXTURES* % BUCCANEER CRUDE	% BRINE DISCHARGE
10/31/77	MIXED CULTURE	2	1	SEDIMENT		10	

% OF REMAINING HYDROCARBONS

ELAPSED TIME	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35	C36	PRISTANE	PHYTANE
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
24	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
48	100	100	100	100	100	100	100	91	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
168	75	57	55	51	52	52	48	47	44	40	37	34	30	30	27	28	31	33	42	47	50	75	40	50	50	46	38
336	NO	100	100	66	54	50	45	41	34	28	23	19	16	12	12	08	04	07	05	07	NO	NO	NO	NO	NO	44	54

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BACTERIA-ENUMERATION

DATE	CRUISE	STATION	SOURCE	TEMPERATURE (C)	SALINITY (PPT)	DISSOLVED OXYGEN (PPM)	PH	TVC COUNT	TVC EXP	% OIL DEGRADERS	% SULPHUR OXIDIZERS	*HEAVY % ZINC	METALS* % CHR.	BIOMASS (GP/ML) COUNT	BIOMASS EXP
7/19/77	1	1	TOP	29.0	34.0	6.0	6.3	1.07	-02	1.03	0.04				
7/19/77	1	1	MIDDLE	30.0	34.0	5.6	6.4	1.60	-02	0.24	0.05				
7/19/77	1	1	BOTTOM	30.0	33.0	6.4	6.4	1.73	-02	0.13	0.17				
7/19/77	1	2	TOP	27.0	34.0	5.2	6.4	.73	-02	0.32	0.04				
7/19/77	1	2	MIDDLE	27.0	34.0	5.2	7.1	1.67	-02	0.14	0.04				
7/19/77	1	2	BOTTOM	27.0	34.0	6.1	6.8	2.93	-02	0.32	0.62				
7/19/77	1	3	TOP	26.0	34.0	5.6	7.4	2.50	-02	4.40	4.40				
7/19/77	1	3	MIDDLE	27.0	34.0	6.8	7.4	.90	-02	0.26	0.17				
7/19/77	1	3	BOTTOM	27.0	34.0	6.1	7.4	1.90	-02	0.23	0.05				
7/19/77	1	4	TOP	26.0	34.0	6.1	7.3	.87	-02	0.95	0.24			7.0	-09
7/19/77	1	4	MIDDLE	27.0	35.0	6.1	7.4	1.27	-02	0.31	0.00			7.6	-09
7/19/77	1	4	BOTTOM	26.0	34.0	5.8	7.3	1.97	-02	0.47	0.06			12.1	-09
7/19/77	1	5	TOP	26.0	32.0	6.2	7.4	1.20	-02	0.36	0.00			2.3	-09
7/19/77	1	5	MIDDLE	27.0	35.0	7.2	7.3	1.33	-02	0.17	0.07			2.9	-09
7/19/77	1	5	BOTTOM	27.0	35.0	8.0	7.4	2.93	-02	0.06	0.22			12.9	-09
7/19/77	1	1	SEDIMENT					1.51	-04	1.50	0.07				
7/19/77	1	2	SEDIMENT					2.35	-05	0.16	0.01				
7/19/77	1	3	SEDIMENT					6.25	-03	0.34	0.00				
7/19/77	1	4	SEDIMENT					1.44	-05	0.16	0.01				
7/19/77	1	5	SEDIMENT					1.32	-05	0.02	0.01				
7/19/77										0.04	0.04				
8/26/77	2	1	TOP	27.0	36.0	6.0		1.00	-02	0.11	0.53	57.0	97.0		
8/26/77	2	1	MIDDLE	27.0	36.0	5.4		3.05	-02	0.05	0.14	10.4	19.7	18.9	-09
8/26/77	2	1	BOTTOM	26.5	37.0	5.8		1.40	-02	0.04	0.66	10.7	100.0	7.6	-09
8/26/77	2	2	TOP	27.0	36.0	6.0		1.90	-02	0.02	0.12	5.3	38.4		
8/26/77	2	2	MIDDLE	27.5	38.0	6.0		2.10	-02	0.02	0.10	17.6	55.7		
8/26/77	2	2	BOTTOM	26.5	36.0	5.0		2.60	-02	0.14	0.29	18.1	47.7		
8/26/77	2	3	TOP	27.5	37.0	4.8		4.40	-02	0.02	0.05	15.2	55.2		
8/26/77	2	3	MIDDLE	27.0	36.0	5.4		6.25	-02	0.01	0.74	9.1	69.6		
8/26/77	2	3	BOTTOM	27.0	37.0	5.2		4.10	-02	0.02	0.10	14.6	65.9		
8/26/77	2	4	TOP	28.0	38.0	5.4		3.50	-02	0.60	0.12	16.3	52.9		
8/26/77	2	4	MIDDLE	29.0	36.0	5.4		2.40	-02	1.63	0.10	19.0	62.6		
8/26/77	2	4	BOTTOM	29.0	37.0	5.6		2.60	-02	0.88	0.17	15.4	69.2		
8/26/77	2	5	TOP	26.5	36.0	5.8		2.45	-02	0.15	0.10	5.3	70.6		
8/26/77	2	5	MIDDLE	24.0	36.0	6.0		5.50	-02	0.07	0.04	6.0	21.6		
8/26/77	2	5	BOTTOM	28.0	36.0	5.9		5.10	-02	0.07	0.06	7.4	52.9		
8/26/77	2	6	TOP	28.0	37.0	5.6		2.10	-02	0.17	0.20	17.6	89.1		
8/26/77	2	6	MIDDLE	27.0	36.0	5.8		3.60	-02	0.09	0.06	19.0	57.1		
8/26/77	2	6	BOTTOM	27.0	37.0	6.1		5.40	-02	85.20	0.40	22.3	64.6		
8/26/77	2	7	TOP	28.0	36.0	5.8		4.80	-02	0.01	0.05	7.7	51.6		
8/26/77	2	7	MIDDLE	28.0	36.0	6.0		4.60	-02		0.09	11.4		22.1	-09
8/26/77	2	7	BOTTOM	28.0	36.0	6.1		5.70	-02		0.04	5.7	55.6	26.6	-09
8/26/77	2	1	SEDIMENT					3.15	-07	0.01	0.01				
8/26/77	2	2	SEDIMENT					1.77	-07	0.01	0.01				
8/26/77	2	3	SEDIMENT					3.66	-06	0.05	0.04				

BACTERIA-ENUMERATION

DATE	CRUISE	STATION	SOURCE	TEMPERATURE (C)	SALINITY (PPT)	******** HYDROGEN SULFIDE % +	% -	% SLANT ACID	KIA %SLANT, ALKALINE	% BUT ACID	******** % BUT ALKALINE	GAS % +	% -	TVC SUSPENDED MATERIAL COUNT	EXP	TVC FILTERED MATERIAL COUNT	EXP
8/26/77	2	3	SEDIMENT														
8/26/77	2	4	SEDIMENT														
8/26/77	2	5	SEDIMENT														
8/26/77	2	6	SEDIMENT														
8/26/77	2	7	SEDIMENT														
11/11/77	3	1	TOP	22.0	33.0									2.60	01	1.10	02
11/11/77	3	1	MIDDLE	22.0	34.0												
11/11/77	3	1	BOTTOM	22.0	34.0									3.00	00	2.10	02
11/11/77	3	2	TOP	22.7	34.0												
11/11/77	3	2	MIDDLE	23.4	34.0												
11/11/77	3	2	BOTTOM	23.0	34.0												
11/11/77	3	3	TOP	22.6	34.5												
11/11/77	3	3	MIDDLE	24.2	34.0												
11/11/77	3	3	BOTTOM	24.5	34.0												
11/11/77	3	4	TOP	24.5	36.0									.00	00	1.20	02
11/11/77	3	4	MIDDLE	23.4	34.0												
11/11/77	3	4	BOTTOM	23.2	34.5									1.00	01	2.90	02
11/11/77	3	5	TOP	22.7	34.0												
11/11/77	3	5	MIDDLE	23.0	34.0												
11/11/77	3	5	BOTTOM	23.8	34.5												
11/11/77	3	6	TOP	24.0	34.5												
11/11/77	3	6	MIDDLE	23.5	34.0												
11/11/77	3	6	BOTTOM	23.2	34.0												
11/11/77	3	7	TOP	23.3	34.0									1.30	01	2.10	02
11/11/77	3	7	MIDDLE	24.0	34.0												
11/11/77	3	7	BOTTOM	26.0	34.0									7.00	00	1.20	02
11/11/77	3	1	SEDIMENT														
11/11/77	3	2	SEDIMENT														
11/11/77	3	3	SEDIMENT														
11/11/77	3	4	SEDIMENT														
11/11/77	3	5	SEDIMENT														
11/11/77	3	6	SEDIMENT														
11/11/77	3	7	SEDIMENT														
2/24/78	4	1	TOP	13.0	32.0									7.00	02	3.70	03
2/24/78	4	1	MIDDLE	13.5	35.0									.00	01	5.00	03
2/24/78	4	1	BOTTOM	14.0	35.0									.00	01	3.30	02
2/24/78	4	2	TOP	13.5	34.0									.00	01	1.20	03
2/24/78	4	2	MIDDLE	13.5	35.0									.00	01	3.50	02
2/24/78	4	2	BOTTOM	14.0	35.0									.00	01	9.00	01
2/24/78	4	3	TOP	13.0	34.0									.00	01	1.80	03
2/24/78	4	3	MIDDLE	14.2	35.0									6.00	01	1.10	02
2/24/78	4	3	BOTTOM	13.5	35.0									.00	01	1.90	02
2/24/78	4	4	TOP	15.0	32.0									.00	01	1.10	03
2/24/78	4	4	MIDDLE	14.5	32.0									.00	01	6.40	02

```
                         BACTERIA-TAXONOMY/PHYSIOLOGICAL DIVERSITY

*********            DATE   CRUISE STATION  SOURCE  STRAIN  GENERA DESIGNATION                    *********
*********                                                                                         *********
                    7/19/77    1       1      TOP      1    PSEUDOMONAS GP3


                        MOF                                                                       FLUORESCENT
   GRAM                  +           FLAGELLA                        CELL            0/129      ARGININE        PIGMENT
  STAIN      MOF        GAS MOTILITY   STAIN      OXIDASE  CATALASE  SHAPE   SPORE SENSITIVITY DECARBOXYLASE    FORMED

   NO     ALKALINE      NO    YES     POLAR         YES      YES     RODS     NO       NO                        NO

                      PROTEOLYTIC CHITINOCLASTIC LIPOLYTIC SALT REG. AMYLASE CELLULOLYTIC

                          NO           NO            YES        NO

*********            DATE   CRUISE STATION  SOURCE  STRAIN  GENERA DESIGNATION                    *********
*********                                                                                         *********
                    7/19/77    1       1      TOP      2    ACINETOBACTER


                        MOF                                                                       FLUORESCENT
   GRAM                  +           FLAGELLA                        CELL            0/129      ARGININE        PIGMENT
  STAIN      MOF        GAS MOTILITY   STAIN      OXIDASE  CATALASE  SHAPE   SPORE SENSITIVITY DECARBOXYLASE    FORMED

   NO     ALKALINE      NO    NO                    NO       YES     RODS     NO       NO                        NO

                      PROTEOLYTIC CHITINOCLASTIC LIPOLYTIC SALT REG. AMYLASE CELLULOLYTIC

                          YES          NO            NO         YES
```

FISH TAGGING

AUGUST 16, 1977 SATELLITE

START TIME	END TIME	CAPTURE DEPTH (FT)	CAPTURE METHOD	BAIT	COMMON NAME	SCIENTIFIC NAME
1425	1655	10 - 30	HOOK/LINE	SHRIMP	SPADEFISH	CHAETODIPTERUS FABER

TAG COLOR	TAG NUMBER	LENGTH (MM)
WHITE	-	277
WHITE	2	232
WHITE	18	187
WHITE	21	259
WHITE	24	181
WHITE	29	179
WHITE	31	230
WHITE	38	236
WHITE	42	187
WHITE	46	337
WHITE	51	228
WHITE	55	255
WHITE	61	280
WHITE	76	192
WHITE	99	215

```
                                                        BIOFOULING

                                             DATE              MARCH 10,1978
                                             LOCATION         *************


                         *****                       TOP                              *****  *****                        BOTTOM                              *****
                         *              ** ENCRUSTING ** STALKED                          *  *              ** ENCRUSTING ** STALKED                              *
  EXP.   WEIGHT  SHELL  *HYDROID  SPONGE  BRYOZOAN    BRYOZOAN  ALGAE  OTHER              *  *HYDROID  SPONGE  BRYOZOAN    BRYOZOAN  ALGAE  OTHER               *
          (GM)   (PCT)  * (PCT)   (PCT)   (PCT)        (PCT)    (PCT)  (PCT)              *  * (PCT)   (PCT)   (PCT)        (PCT)    (PCT)  (PCT)               *
 QET1B    10.3     90       30      <10                          <20     50      AT
 QET2B    20.8     70       90        0       0            0      10      0
 QET3B    15.6     80       20       20       0            0      20     40      AT
 QET4B    23.3     90       40        0       0            0      20     40      AT
 QWT1B    18.9     80        0       20       0            0      70     10      AT
 QWT2B    17.1     80       20       20       0            0      60      0
 QWT3B    21.7     70       90        0       0            0      10      0
 SEB1B     1.3      0       10       80      10            0       0      0                       0      90      10           0        0      0
 SEB2B      .9      0       20       80       0            0       0      0                              50      50           0        0      0
 SEB3B     1.2      0      <10      >90       0            0       0      0                             >90     <10           0        0      0
 SEB4B     1.2      0       10       80       0            0       0     10      CA                      80      20           0        0      0
 SEM1B    10.7     60        0        0       0          100       0      0
 SEM2B    18.5     70        0       10       0           90       0      0
 SEM3B    12.1     50       10       30       0           50       0     10      AT               0     100       0           0        0      0
 SEM4B     3.3      0        0       30       0           70       0      0
 SWB1B     6.3      0        0      100       0            0       0      0                       0      40      60           0        0      0
 SWB2B     2.3      0        0      100       0            0       0      0                       0      60      40           0        0      0
 SWB3B     3.2      0       10       80       0            0       0     10      CO               0      20      50           0        0      0
 SWB4B     1.8      0      <10      >90       0            0       0      0                       0      50      40           0        0      0
 SWM1B    16.9     30      <10      <20       0           80       0      0
 SWM2B    19.5     40        0        0       0          100       0      0
 SWM3B    34.1     40        0        0       0          100       0      0
 SWM4B    16.1     10        0        0       0          100       0      0
```

BIOFOULING

DATE FEBRUARY 4,1978
LOCATION PLATFORM
EXPERIMENT CE32B

VIAL	NUMBER OF INDIVIDUALS	WEIGHT (GM)	TAXA
2A	2	.5	SYNSYLLIS LONGIGULARIS
2B	1	.4	HAPLOSYLLIS SPONGICOLA
2C	5	2.3	TRYPANOSYLLIS GEMMIPARA
2D	5	6.1	AUTOLYTUS SP 2
2E	1	2.2	POLYDORA CILIATA
2F	3	3.6	THELEPUS SETOSUS
2G	5	1.4	COROPHIUM SP
2H	1	.4	LEUCOTHOE SPINICARPA
2I	1	.2	AMPHIPOD B
2J	5	36.9	CAPRELLID
2K	1	7.0	HEXAPANOPEUS PAULENSIS
2L	5	10.0	CHAMA MACEROPHYLLA
2M	2	.1	ANEMONE 2
2N	3	4.5	NEMATODA

FOOD HABITS

DATE	AUGUST 16, 1977
LOCATION	PLATFORM A PRODUCTION
SCIENTIFIC NAME	CHAETODIPTERUS FABER
COMMON NAME	SPADEFISH

MEASURED INDIVIDUALS

SAMPLE NUMBER	TIME CAUGHT	TIME SACRIFICED	LENGTH (MM)	WEIGHT (GM)	SEX
28A	500	500	254	512	MALE
29A	700	700	278	734	FEMALE
30A	900	900	233	422	FEMALE
31A	900	900	215	349	FEMALE
32A	900	900	198	278	FEMALE
33A	1100	1100	251	533	MALE
34A	1100	1100	225	398	MALE
35A	1100	1100	212	332	MALE
201	2330	2330	255	505	FEMALE
202	2330	2330	280	638	FEMALE
203	2330	2330	290	770	FEMALE
201	2330	2330	255	505	FEMALE

```
                       *FOOD HABITS - STOMACH CONTENTS*

DATE              LOCATION                 ***TIME****         BIONUMERIC CODE
                                           START   END
08/15/77       PLATFORM A PRODUCTION       2100   2110           1702=C101

        COMMON NAME              LENGTH     WEIGHT            SEX      CONTENTS
                                  (MM)       (GR)                     WEIGHT(GR)
   ATLANTIC SPADEFISH             275        640             FEMALE        .09

                 STOMACH CONTENTS TAXA                    % OF TOTAL
          BARNACLE MOLTS                                      80
          STOMATOPOD LARVAE                                    5
          ANOMURAN ZOEA                                        5
          UNIDENTIFIED                                        10
```

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DRIFT BOTTLE RELEASE/RECOVERY LOG

CRUISE NUMBER	BOTTLE NUMBER	BALLAST	***** ***** DATE	RELEASE DATA LATITUDE DEG	MIN	LONGITUDE DEG	***** ***** MIN	***** ***** DATE	RECOVERY DATA LATITUDE DEG	MIN	LONGITUDE DEG	***** ***** MIN	DAYS OUT	DISTANCE (KM)	* RATE * (KM/DAY)	LOCATION OF WORK
176	48	Y	5/25/76	28	37.5	94	28.0	7/19/76	26	37.5	96	4.0	55	164.8	3.0	NORTHWEST GULF OF MEXICO
176	49	Y	5/25/76	28	37.5	94	26.0									
176	50	Y	5/25/76	28	25.8	94	17.5	8/10/76	29	46.2	93	28.4	78	170.4	2.2	NORTHWEST GULF OF MEXICO
176	51	Y	5/25/76	29	24.2	94	43.4	11/18/76	29	24.2	94	47.4	177	116.7	.6	NORTHWEST GULF OF MEXICO
176	52	Y	5/25/76	28	25.8	94	17.5	8/15/76	29	46.2	93	28.4	82	170.4	2.1	NORTHWEST GULF OF MEXICO
176	53	Y	5/25/76	28	25.8	94	17.5	9/ 1/76	29	5.4	95	6.5	100	109.7	1.1	NORTHWEST GULF OF MEXICO
176	54	Y	5/25/76	28	25.8	94	17.5									
176	55	Y	5/25/76	28	25.8	94	17.5									
176	56	Y	5/26/76	28	9.3	94	46.0	7/22/76	28	51.5	95	30.0	57	103.7	1.8	NORTHWEST GULF OF MEXICO
176	57	Y	5/26/76	28	9.3	94	46.0									
176	58	Y	5/26/76	28	9.3	94	46.0	6/29/76	28	36.5	95	58.0	31	131.5	4.2	NORTHWEST GULF OF MEXICO
176	59	Y	5/26/76	28	9.3	94	46.0									
176	60	Y	5/26/76	28	9.3	94	46.0									
176	61	Y	5/26/76	28	9.3	94	46.0									
176	62	Y	5/27/76	28	20.7	94	56.7									
176	63	Y	5/27/76	28	20.7	94	56.7	6/27/76	28	36.7	95	56.0	27	102.6	3.8	NORTHWEST GULF OF MEXICO
176	64	Y	5/27/76	28	20.7	94	56.7	7/ 2/76	28	45.5	95	37.5	36	81.5	2.3	NORTHWEST GULF OF MEXICO
176	65	Y	5/27/76	28	20.7	94	56.7	6/18/76	28	20.5	96	23.5	22	140.7	6.4	NORTHWEST GULF OF MEXICO
176	66	Y	5/27/76	28	20.7	94	56.7	6/28/76	28	39.5	95	49.5	32	96.3	3.0	NORTHWEST GULF OF MEXICO
176	67	Y	5/27/76	28	20.7	94	56.7									
176	68	Y	5/27/76	28	32.5	95	7.0									
176	69	Y	5/27/76	28	32.5	95	7.0									
176	70	Y	5/27/76	28	32.5	95	7.0									
176	71	Y	5/27/76	28	32.5	95	7.0									
176	72	Y	5/27/76	28	32.5	95	7.0									
176	73	Y	5/27/76	28	32.5	95	7.0									
176	74	Y	5/28/76	28	44.0	95	18.0	6/ 4/76	29	11.5	94	57.5	7	60.2	8.6	NORTHWEST GULF OF MEXICO
176	75	Y	5/28/76	28	44.0	95	18.0	6/10/76	28	53.5	95	21.5	13	18.5	1.4	NORTHWEST GULF OF MEXICO
176	76	Y	5/28/76	28	44.0	95	18.0									
176	77	Y	5/28/76	28	44.0	95	18.0									
176	78	Y	5/28/76	28	44.0	95	18.0	6/ 5/76	29	13.0	94	55.0	8	63.0	7.9	NORTHWEST GULF OF MEXICO

DYE STUDY

EXPERIMENT	*PLATFORM A*	*RELEASE* DATE	TIME	*DISTANCE (FROM PLATFORM)	BEARING*	*BOTTOM DEPTH*
SUMMER		8/17/77	1400	3.0KM	354(DEG)	18M

DATE	TIME	DISTANCE (KM)	BEARING (DEG)	MAJOR AXIS LENGTH (M)	MAJOR AXIS ORIENTATION (DEG)	MINOR AXIS LENGTH (M)	MINOR AXIS ORIENTATION (DEG)	AREA 10**3 M**2	PENETRATION (M)
8/17/77	1400	3.0	354	27	0 180	37	90 270	0.59	
8/17/77	1415	3.1	354		0 180	47	90 270	2.09	
8/17/77	1430	3.1	3	130	0 180		90 270	4.44	
8/17/77	1445	3.1	3		0 180		90 270	6.02	
8/17/77	1500	3.2	360	255	0 180	85	90 270	12.68	
8/17/77	1515	3.2	5	345	0 180		90 270	20.16	
8/17/77	1530	3.3	360		0 180		90 270	34.74	
8/17/77	1545	3.3	4		0 180		90 270	41.28	
8/17/77	1600	3.4	4	540	0 180	95	90 270	45.70	4.0
8/17/77	1615			555	0 180		90 270	51.42	
8/17/77	1630	3.7	355		0 180		90 270	63.77	
8/17/77	1645	3.9	3		0 180	130	90 270	75.70	
8/17/77	1700	3.9	355	740	0 180		90 270	88.27	
8/17/77	1715	4.1	3	845	0 180	150	90 270	106.75	4.0

```
                          *TRANSPONDING BUOY DATA,

*CRUISE NO.*   *BUOY NO.*   *CURRENT DEPTH*    **********RELEASE DATA**********    *********RESULTANT DRIFT*********
   005-77          19            1.0(M)           DATE     TIME    LAT.      LONG       DIRECTION(DEG)    SPEED(N.M./DAY)
                                                 6/18/77    145   28 52.0   94 41.5          44               .3

           DATE      TIME    LONG       LAT.      DIR(DEG)      DIS(N.M.)   SPEED(KNOTS)
          6/19/77    1725   94 30.4   28 59.5       46            12.5           .3
          6/20/77    1240   94 12.8   29  4.2       68            16.0           .8
          6/21/77    1210   93 56.4   29  7.7       69            15.0           .6
          6/22/77    1105   94 10.5   29 14.0      290            14.0           .6
```

```
                                        OCEANOGRAPHIC STATIONS

                      CRUISE   STATION                                 MARSDEN                       BOTTOM   ***** WIND       *****
  DATE        TIME    NUMBER   NUMBER     LATITUDE     LONGITUDE       SQUARE        SHIP            DEPTH    DIRECTION        SPEED
              (GMT)                       DEG  MIN     DEG  MIN                                       (M)      (DEG)           (KT)
 7/14/77      5.5      677        5       28 51.1       94 42.4           82         GUS III           20     115 TO 124        15
                                          *****    SUBSURFACE OBSERVATIONS    *****
                                          NUMBER   DEPTH    TEMPERATURE    SALINITY
                                                    (M)        (C)          (PPT)
                                            2      20.40      23.00         34.00

                      CRUISE   STATION                                 MARSDEN                       BOTTOM   ***** WIND       *****
  DATE        TIME    NUMBER   NUMBER     LATITUDE     LONGITUDE       SQUARE        SHIP            DEPTH    DIRECTION        SPEED
              (GMT)                       DEG  MIN     DEG  MIN                                       (M)      (DEG)           (KT)
 7/14/77      18.3     677        8       28 49.0       ** 61.0          167         GUS III           21     105 TO 114        10
                                          *****    SUBSURFACE OBSERVATIONS    *****
                                          NUMBER   DEPTH    TEMPERATURE    SALINITY
                                                    (M)        (C)          (PPT)
                                            1        .00      25.50         34.90
                                            2      21.00      24.50         36.00

                      CRUISE   STATION                                 MARSDEN                       BOTTOM   ***** WIND       *****
  DATE        TIME    NUMBER   NUMBER     LATITUDE     LONGITUDE       SQUARE        SHIP            DEPTH    DIRECTION        SPEED
              (GMT)                       DEG  MIN     DEG  MIN                                       (M)      (DEG)           (KT)
 7/14/77      19.5     677        3       28 52.6       94 41.9           82         GUS III           20     095 TO 104        10
                                          *****    SUBSURFACE OBSERVATIONS    *****
                                          NUMBER   DEPTH    TEMPERATURE    SALINITY
                                                    (M)        (C)          (PPT)
                                            1        .00      30.00         35.50
                                            2      20.40      23.50         35.50
```

```
                                           *TRACE METALS*


                              STATION NAME      DATE      LATITUDE    LONGITUDE
                                 JCMT M        1/22/77    28 51.50    94 42.62

******************************* SAMPLE ******************************          SAMPLE DEPTH     ORGAN ANALYZED
NUMBER      TYPE          COMMON NAME               SCIENTIFIC NAME                  5.0
 E27      ORGANISM     BARNACLES                BALANUS


                                            CONCENTRATION IN PPM

MANGANESE     COPPER      ZINC     CHROMIUM      LEAD      CADMIUM     BARIUM     NICKEL     IRON     STRONTIUM   ORGANIC CARBON
   13.75       13.75     206.25    *  1.00       5.75      11.00


 PRECEEDING  *  INDICATES VALUE IS LESS THAN GIVEN VALUE.
```

Work Unit 2.3.4 Bioassay of Buccaneer Oil Field Effluents with Penaeid Shrimp

NMFS/SEFC Galveston Laboratory

Zoula P. Zein-Eldin

Peggy M. Keney

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ABSTRACT

Brown (*Penaeus aztecus*) and white (*P. setiferus*) shrimp of several sizes were exposed to concentrations of Buccaneer Oilfield produced brine effluents ranging from 1,000 to 500,000 ppm (v/v) in 96-hour static bioassays. LD50's ranged from 3,000 to >10,000 ppm during the months of the test (August 1977 through March 1978). Long-term tests with feeds soaked in effluents suggested that such exposure might predispose to stress in subsequent acute exposure tests.

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INTRODUCTION

This study was started in the summer 1977 to provide laboratory information complementing field observations of the possible toxicity of Buccaneer Oilfield produced brine effluents. Experiments were conducted with two species of penaeid shrimp native to the Gulf of Mexico, the white shrimp, (*Penaeus setiferus*) and the brown shrimp (*P. aztecus*). Both species play an important part in the fisheries industry and hence the economy of the Gulf area. Since the adult and larval phases of the life cycle of these animals takes place in the offshore regions of the Gulf, both short-term and long-term effects of produced brine effluents would be of interest.

The objectives of this study were three-fold: (1) to determine the 96-hour survival of penaeid shrimp exposed to varying concentrations of Buccaneer Oilfield effluents; (2) to determine whether there were differences in response to the effluent with season, with size of test animal, and with species of test animal; and (3) to attempt to demonstrate long-term effects of effluents upon penaeids.

EFFLUENT SAMPLES

The study area and the platforms from which the produced brine effluents were obtained have been described by other investigators (Harper, D. E., Jr., 1978). Effluent samples were obtained from both Platforms 288-A and 296-B from July through October of 1977. Subsequent samples (November 1977 through February 1978) came solely from Platform 296-B following changes in operational procedures by Shell Oil Company.

Effluent was collected in clean glass bottles of about 2-1 capacity, covered with aluminum foil and fitted with a tight cap. Whenever possible, samples were refrigerated after collection until returned to the laboratory, where samples were either refrigerated or frozen until testing. A single initial sample of about 20-1 of effluent was taken for preliminary testing.

The initial sample mentioned above was collected approximately 20 days before our first test, and was stored at room temperature (approximately 25°C) during this time. It was noted that the yellow precipitate originally observed in the effluent had darkened and become black by the time of the test. The presence of precipitate in later samples, as well as the color of the suspended material, varied both between production platforms and with data of collection (Table 1).

PRELIMINARY TESTING

Preliminary testing began in July 1977 with experiments to define the limits of toxicity of the effluent. In this series of tests Buccaneer produced brine effluent was tested at concentrations of 500,000; 100,000; 10,000; 1,000 and 1 ppm (volume of effluent/volume of diluent). Although salinity of the brine (35.5 o/oo) tested was within limits usually tolerated by these animals, to ensure that salinity change was not a cause of mortality, natural sea water obtained from the laboratory system filtered through a 5-u filter passed over an ultraviolet light was brought to the same salinity with concentrated sea water and then used as test medium at 500,000 and 100,000 ppm.

As a further test, both salinity-adjusted sea water and brine effluent were treated with Buccaneer Oilfield petroleum hydrocarbons. Four parts sea water or effluent were mixed with one part petroleum and stirred on a magnetic stirrer for 10 minutes. The resulting emulsions were placed in spearatory funnels, allowed to stand for 30 minutes, and the aqueous layers drained off and diluted for testing. Petroleum treated brine was tested at 500,000 and 100,000 ppm; salinity-adjusted sea water (as described above) at 500,000, 100,000 and 10,000 ppm (Table 2).

All effluents and test solutions as described were diluted with natural sea water aerated for 2-3 days. Salinity of this water was 25 o/oo, and was identical to that in which the experimental animals were maintained.

The experimental white shrimp were hatched and reared in this laboratory; at the date of the range-finding experiment, test animals averaged 28.26 mm in total length (from tip of rostrum to tip of telson) and ranged from 21-34.5 mm. Five animals were placed in 500 ml test medium contained in a 1000 ml glass beaker, with two beakers (10 animals) per test solution. Medium was neither aerated nor changed during the test, nor were animals fed.

In the first stage of the test, white shrimp (_P. setiferus_) were exposed to 500,000 ppm effluent; 500,000 ppm effluent saturated with petroleum; 100,000 ppm effluent; 100,000 ppm effluent saturated with petroleum; 500,000 ppm salinity-adjusted sea water; 500,000 ppm salinity-adjusted sea water saturated with petroleum; and natural sea water alone (0 ppm effluent) as a control.

Within 10 minutes of exposure, animals subjected to both 500,000 ppm petroleum-saturated effluent and salinity-adjusted sea water were moribund; i.e., they were lying on their sides with no indication of pleopod motion unless stiumlated with a glass rod. All animals in these solutions were dead (no response to stimulation with glass rod; no visible heart beat) within 45 minutes of exposure. Animals in 500,000 ppm effluent showed immediate stress (hyperactivity; erratic swimming movements) within 10 minutes, and all were dead within 3 hours. Animals exposed to 100,000 ppm effluent showed no signs of stress during the first 4 hours, but were dead within 20.5 hours, while animals in the 100,000 effluent saturated with petroleum showed immediate stress, with 20% moribund within 45 minutes. Two deaths (20%) occurred within 4 hours. All of these animals had also died 20.5 hours after exposure. Of this group of experimental animals, only those exposed to 500,000 ppm salinity-adjusted water and animals in natural sea water survived 24 hours of observation (Table 2).

Because test concentrations as described were too high to permit 96-hour survival, the test was repeated using effluent concentrations of 10,000, 1,000 and 1 ppm. Salinity-adjusted water had been shown to be virtually non-toxic at 500,000 ppm thereby eliminating salinity change as cause of stress and death; therefore, lower concentrations of this water were not tested. To further test the effect of hydrocarbons, petroleum-saturated salinity-adjusted water was tested at 100,000 and 10,000 ppm. As contrasted with the animals in the range-finding experiment, no signs of stress were noted during the first 4 hours among any animals exposed in the second test. Seventy per cent of the animals exposed to 10,000 ppm effluent were dead 20.5 hours after exposure, but no more than 20% of the animals exposed to any of the other conditions were affected. Of the six animals that died at the lower concentrations, five died following a molt and had been partially eaten by other animals in the beaker. At the end of 96-hours, during which the water was not changed or aerated, survival was 80-90% under all test conditions except 10,000 ppm effluent which had no survival and natural sea water which had 100% survival. This experiment established that 10,000 ppm was the upper limit at which concentrations of effluent needed to be tested, and suggested that the addition of petroleum to brine effluents made it more toxic than petroleum in natural sea water.

96-HOUR BIOASSAYS

Methods

Static bioassays were conducted according to the general methods outlined by the EPA (1976). Ten animals were used per test concentration, the number per beaker varying with the size of the animal and series (Table 3). One liter glass beakers containing 500 ml test medium were used. Beginning in September, test solution was replaced daily to ensure more constant levels of exposure to effluent and adequate oxygen supply, and to reduce the possibility of death from accumulation of toxic metabolites.

All test media (dilutions) were prepared using sea water from the laboratory circulating system, aerated for several days prior to test. Experimental beakers were covered with 6 mil polyethylene film, both to prevent test animals from jumping out of the beaker while in stress and to reduce evaporation with consequent loss of test material and change in salinity.

All experimental animals, both white and brown shrimp, were hatched in the laboratory and maintained at salinities of 25-33 o/oo and temperatures ranging from 23-26°C. Experiments were conducted in controlled temperature rooms at 25°C±1°C and salinities of 25 0/00. Test concentrations ranged from 1,000 to 50,000 ppm (Table 4), based upon the preliminary range-finding experiment.

Beginning in November, oxygen concentrations of the media were measured daily just before the medium was replaced. A Yellow Springs Instrument Model 57 oxygen meter was used. Measurements were made only in beakers in which shrimp survived, since bacterial decomposition could not be eliminated as major contributions to oxygen depletion in the presence of dead shrimp.

Results

Toxicity of brine effluent varied slightly with date of collection, collection site, and species (Table 3). The most marked change in toxicity appeared in the sample collected in October at which time no biocide was being added to the effluent from Platform 288-A (personal communication, Mr. J. A. Burgbacher, Shell Oil Company). Concentrations of 10,000 ppm effluent from Platform 288-A permitted survival of 70% of the small and 60% of the larger shrimp (61.1 mm average length) tested (Table 4). Effluent from Platform 296-B retained its toxicity with 25% of the smaller animals and 20% of the larger ones surviving 10,000 ppm.

Critical concentrations for the brine effluent collected in 1977 seemed to fall between 5,000 and 10,000 ppm (except the October sample), and were between 1,000 and 5,000 ppm for the two samples collected in January and February, 1978. Hydrocarbon and trace metal analyses of the effluents have not been available for comparison with survival data. Also, no biocides were being added to the produced brine when the October sample was taken (see above).

Oxygen concentration measurements indicated that there was a significant increase in average daily oxygen consumption with time of exposure ($P \leq$ than 0.01), but no significant difference occurred in oxygen consumption between control animals and those in effluent concentrations too low to cause mortality (Table 5).

LONG-TERM EFFECTS

Methods

Groups of ten white shrimp (50.2 mm mean length) were placed in each of six glass aquaria, 20 x 40 x 20 cm, fitted with subsurface filters, and containing oyster shell and sand substrate (Zein-Eldin and Aldrich, 1965) and 14 l of natural sea water. All groups were given a prepared feed (Fenucci and Zein-Eldin, 1976), first weighed, then soaked 30 minutes in one of three media: natural sea water; brine effluent (obtained November 14, 1978); and brine effluent (obtained December 22, 1977). Two groups of shrimp, selected at random, were given each treatment. All groups were fed at the same rate, 0.5 g dry feed twice each day. Feeding was continued for 42 days, which included at least two complete molt cycles of the surviving shrimp.

Results

Animals given effluent-soaked feed survived and grew as well as animals given feed soaked in natural sea water. Response to the presence of feed appeared to be as rapid among animals given the effluent-soaked feed as among the controls. Molting oxcurred among all groups, with no apparent difference between test media. Survival was approximately the same among all groups: 55% for control shrimp (feed soaked in sea water), 60% among animals given feed soaked in effluent collected November 4, and 65% among animals given feed soaked in effluent collected December 22.

Surviving animals were maintained in the aquaria for an additional 14 days, and were fed unsoaked, untreated dry feed. At the end of this period, half of each group was challenged in a 96-hour tolerance test using 5000 ppm of effluent obtained January 29, 1978 (Table 6). Both survival and oxygen consumption differed between control animals subjected only to the 96-hour bioassay and those previously held and exposed to effluent-soaked feed. Those animals that previously ingested effluent-soaked feed used more oxygen daily when further stressed with 5,000 ppm effluents than did animals previously ingesting effluent-soaked feed but exposed only to nautral sea water during the 96-hour test. Differences in oxygen consumption between animals in natural sea water and in effluent continued throughout the 96-hours for animals that previously ingested effluent-soaked feed, but were not significant either after 72 or 96 hours among animals previously ingesting only sea water-soaked feed, nor among those animals in the simultaneous 96-hour bioassay using the same effluent (Table 7).

It appears that long-term exposure of shrimp to effluent-soaked feed may predispose them to exhibit stress upon additional exposure to test media, whether in the form of increase in oxygen consumption or in actual death. It is of interest, however, that both groups of animals that were held in small aquaria (Table 6) for approximately 8 weeks prior to the bioassay showed lower mortality rates than did those confined for the first time at the start of the bioassay. Whether this is an adaptation to reduced container size exhibited by the animals given feed containing effluents remains to be studied.

FACTORS AFFECTING THE BIOASSAY

Biological

In crustaceans, the exoskeleton is replaced periodically through molting, premitting growth of the animal. The process is cyclic, the duration of the cycle varying with temperature, size and other characteristics of the animal, and species. Although it is possible to determine the stage of the molt cycle in indivisual animals (Schafer, 1968) it requires considerable handling of each animal, a procedure which increases stress. To prevent the additional stress prior to the addition of test media, animals were randomly assigned to experimental treatments without regard to pre-molting stage.

It was inevitable that some animals would molt during the 96-hour bioassays, with two resulting problems: (1) some newly molted animals were eaten by others when two or more animals were placed in a beaker; and (2) oxygen level in the medium was reduced because of the additional oxygen required by the animal during the molting process (Zein-Eldin, 1960). Observed molting varied among the experiments, with a single molt found in the test of July 18 (Table 8) and 37 molts in the series of October 31 (effluent collected October 28). Therefore, survival following molting was greater in the later experiments in which only one or two animals were placed in a beaker (Table 8). Of 27 animals molting during the first three series (including the preliminary range-finding experiment), only 5 survived, for a survival rate of 18% among animals molting in beakers containing 5 animals. Among groups containing 2 animals, 25 individuals survived 46 molts (54%), but 51 animals of those placed one per container survived 72 molts (61%).

Because of the dependence between number of animals in the container and their survival following the stress of molting, it is strongly recommended that single animals be used in test containers, with appropriate replication, when juvenile penaeids (25 mm or greater total length) are to be used as bioassay organisms.

Physical Characteristics of the Effluent

There was some indication that the suspended matter in the brine effluent was more toxic than the shole effluent (Table 9). Thus, only supernatant fluid was used in the second series in which effluent collected on June 26 was retested. In this experiment 60% of the animals survived 10,000 ppm effluent, although no animals had survival the addition of 10,000 ppm whole effluent only one week earlier.

To test the hypothesis of greater toxicity of the whole effluent, one further test was made on September 1, again using the June 26 effluent which had been stored at room temperature (°C- Table 9). It is apparent that there were no significant differences in effect between the whole brine and the supernate; however, true effects may well have been confounded both by the use of 5 animals per beaker and by the long period of storage. More definitive experiments should be conducted to separate suspended material by either centrifugation of filtration, then resuspending it at known concentrations in natural sea water for toxicity comparisons against both supernatant fluid alone and whole effluent.

Addition of Petroleum Hydrocarbons to the Brine Effluent

The addition of petroleuy hydrocarbons brought about a dramatic decrease in the time until death at the higher concentrations tested (Table 2), as noted particularly in the preliminary test. Subsequent experiments yielded less certain results (Table 4), particularly in the experimental series in which 5 animals were placed in each test beaker. A picture more like that of the preliminary test occurred in the test of the effluent collected on August 21 with larger white shrimp (P. setiferus) (Table 10). In this experiment mortality was both higher and occurred more rapidly in the presence of added petroleum than in the same effluent without additional petroleum. Experiments with petroleum addition were discontinued when we began daily water changes because of the limited amount of effluent available.

DISCUSSION

LD_{50}'s reported here for penaeid shrimp are much higher than those reported using various crude oil mixtures (Heitz et al., 1974; Tatem, Cox, and Anderson, 1978). The important difference is that our tests have been conducted using actual discharge fluids rather than with purified components and were performed in natural sea water, not in artificial sea waters used in the other references cited above.

Heitz et al. (1974) state that the level of oil toxicity is related to season and/or salinity, but the previous handling of their animals which were obtained from nature and subjected to several changes in both salinity and temperature prior to test make these statements difficult to assess. Unlike Tatem, Cox and Anderson (1978) who acclimated the animals for 7-14 days prior to test, Heitz et al. (1974) made no mention of acclimation prior to testing, nor do they discuss the procedure for emulsifying the oil dispersions. Both authors reported LD_{50}

values of 2 to 35 ppm, considerably lower than those determined using the Buccaneer brine effluent mixed with petroleum as described.

The long-term tests suggested that exposure to ingested effluents may well predispose penaeids to stress in subsequent acute exposure tests. Middleditch, Basile and Chang (1978) reported the presence of petroleum hydrocarbons in brown shrimp (*P. aztecus*) obtained from areas near the Buccaneer Oilfield production platforms. Brown shrimp were abundant as postlarvae (Harper, 1978) and juveniles (Emiliani et al., 1978) in the area. It is thus possible for penaeids to be exposed to contaminants in sea water, sediments or food items in the area.

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APPENDIX

TABLE 1. Source and physical characteristics of produced brine effluents tested.

SAMPLE COLLECTION DATE	PRODUCTION PLATFORM	COLOR AND PHYSICAL CHARACTERISTICS	SALINITY (o/oo)
06/26/77	296-B	Yellow; black when tested	36
07/15/77	288-A	Yellow; some suspended particles	48
	296-B	Yellow; some suspended particles	35
08/21/77	288-A	Black; turbid	51
	296-B	Slightly yellow; turbid	36
09/18/77	288-A	Black; turbid	32
	296-B	Clear; with yellow particles	32
10/28/77	288-A	Yellow; clear	42
	296-B	Black; turbid	40
11/14/77	296-B	Yellow; slightly turbid	42
12/22/77	296-B	Grey; slightly turbid	41
01/29/78	296-B	Yellow; slightly turbid	40
02/28/78	296-B	Grey; turbid	42

TABLE 2. Range finding bioassay with produced brine effluent collected on June 26, 1977. Test were conducted July 12, 1977 except where otherwise noted.

CONCENTRATION (ppm, V/V)[a]	UNTREATED			PETROLEUM TREATED			
	EFFLUENT		SALINITY ADJUSTED	EFFLUENT		SALINITY-ADJUSTED	
	Time to 100% Mortality, Hours	96-Hour Survival %	96-Hour Survival %	Time to 100% Mortality, Hours	96-Hour Survival %	Time to 100% Mortality Hours	96-Hour Survival %
0	b	100	-	1.5[c]	0		
1	-	80	-	-	-	-	-
1000	-	90	-	-	70[c]		
10,000	>24 <29	0	-	-	50[c]	-	80
100,000	>5 <21	0	-	>3 <20	0	-	70
500,000	<3	0	60[d]	.75	0	.75	0

[a] Aerated natural seawater used to dilute brine

[b] Not tested

[c] Tested 07/18/76

[d] Two shrimp molted and were eaten

TABLE 3. Summary of experimental protocol and results of bioassays of Buccaneer Oilfield produced brine effluents.

SAMPLE COLLECTION DATE	PRODUCTION PLATFORM	SPECIES	NO. SPECIMENS PER CONTAINER	NO. OF CONTAINERS	MEAN SIZE TOTAL LENGTH (mm)	LD_{50} (ppm)
06/26/77	296-B	white shrimp (*P. setiferus*)	5	2	28.3	3000
07/15/77	288-A	white shrimp (*P. setiferus*)	5	2	29.8	3500
	296-B	white shrimp (*P. setiferus*)	5	2	29.8	3500
08/21/77	288-A	white shrimp (*P. setiferus*)	5	2	29.6	1000[a]
			2	5	48.2	4500[a]
	296-B	white shrimp (*P. setiferus*)	5	2	29.6	1000[a]
			2	5	48.2	6000[a]
09/18/77	288-A	white shrimp (*P. setiferus*)	1	10	59.3	6000
		brown shrimp (P. aztecus)	1	10	55.2	3800
	296-B	white shrimp (*P. setiferus*)	1	10	59.3	6500
		brown shrimp (P. aztecus)	1	10	55.2	6000
10/28/77	288-A[b]	white shrimp (*P. setiferus*)	2	10	37.1	>10,000
			1	10	61.1	>10,000
	296-B[b]	white shrimp (P. setiferus)	2	10	37.1	7000
			1	10	61.1	5000

(Cont'd)

TABLE 3. Summary of experimental protocol and results of bioassays of Buccaneer Oilfield produced brine effluents.

SAMPLE COLLECTION DATE	PRODUCTION PLATFORM	SPECIES	NO. SPECIMENS PER CONTAINER	NO. OF CONTAINERS	MEAN SIZE TOTAL LENGTH (mm)	LD_{50} (ppm)
11/14/77	296-B	white shrimp (*P. setiferus*)	1	10	58.7	6500
12/22/77	296-B	white shrimp (*P. setiferus*)	1	10	58.7	5000
01/29/78	296-B	white shrimp (*P. setiferus*)	1	10	64.4	1750
02/28/78	296-B	white shrimp (*P. setiferus*)	1	10	64.4	2100

[a] Control (0 ppm) survival for 96-hours was very poor; these values are given for 24-hours only.

[b] No biocides were being added when this sample was collected.

TABLE 4. 96-hour survival (%) of penaeid shrimp exposed to various concentrations of Buccaneer Oilfield produced brine effluents. White shrimp (Penaeus setiferus) used as test animals unless otherwise indicated (refer to Table 3 for shrimp size).

Sample Collection Date	Production Platform	Control 0 %	Effluent 1000 %	Petroleum Treated 1000	5000 %	Effluent 10,000 %	Petroleum Treated 10,000	50,000 %	100,000 %
07/15/77	288-A	70	90	100	-[b]	10	10	-	-
	296-B	70	70	70	-	20	0	-	-
08/21/77	288-A	45	30	60	-	0	0	-	-
	288-A	20	50	30	-	0	0	-	-
	296-B	45	30	70	-	20	50	-	-
	296-B	20	46	50	-	10	0	-	-
09/18/77	288-A	100	80	-	70	0	-	-	-
	A[c]	90	80	-	40	0	-	-	-
	296-B	100	100	-	80	0	-	-	-
	296-B[c]	90	80	-	80	0	-	-	-
10/28/77	A	90	85	-	75	70	-	-	-
	A	100	90	-	90	60	-	-	-
	296-B	90	90	-	75	25	-	-	-
	296-B	100	90	-	50	20	-	-	-
11/14/77	296-B	80	-	-	80	0	-	0	0
12/22/77	296-B	80	-	-	50	0	-	0	0
01/29/78	296-B	90	60	-	30	0	-	-	-
02/28/78	296-B	90	90	-	0	0	-	-	-

[a] See text for explanation

[b] Concentration not tested

[c] Penaeus aztecus

TABLE 5. Oxygen concentration (ppm) in the medium of white shrimp (P. setiferus) exposed to Buccaneer Oilfield produced brine effluents during a 96-hour bioassay.[a]

TEST DATE	SAMPLE COLLECTION DATE	BRINE EFFLUENT CONCENTRATION (ppm)	24 Hours		48 Hours		72 Hours		96-Hours	
			No. Shrimp	O_2 ppm*	No. Shrimp	O_2 ppm*	No. Shrimp	O_2 ppm*	No. Shrimp	O_2 ppm*
01/17/78		0	10	2.54±0.55	9	1.90±0.54	9	2.71±0.49	6	3.39±-.87
	11/17/78	5000	10	2.71±0.67	9	2.72±0.62	9	2.96±0.82	6	3.72±0.87
	12/22/77	5000	10	2.56±0.75	9	2.11±0.78	5	3.39±0.63	5	3.62±0.82
03/06/78		0	19	1.98±0.41	20	2.05±0.79	19	2.76±1.09	18	3.33±0.74
	01/29/78	5000	10	2.40±0.83	8	1.92±0.72	8	3.01±0.69	6	3.00±0.74
	02/28/78	5000	10	1.77±0.58	9	2.12±0.75	9	2.81±0.76	9	2.62±0.95

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[a] Data from October sample not included; oxygen measurements were taken every other day.

*Mean ± standatd deviation; includes only those measurements made on media containing a single live animal that had not molted during the 24-hour period. Medium changed after oxygen measurement.

TABLE 6. 96-hour survival (%) of white shrimp given produced brine effluent-soaked feed for 42 days prior to exposure to produced brine collected January 1978.

PREVIOUS CONTAINER SIZE	PREVIOUS TREATMENT	CONCENTRATION OF EFFLUENT	
		0 ppm	5,000 ppm
20 x 40 x 20 cm	Feed soaked in seawater	80	83
20 x 40 x 20 cm	Feed soaked in produced brine effluent	100	54
180 cm diam. x 40 cm	No acclimation; unsoaked dried feed	90	30

TABLE 7. Oxygen concentration in the medium during a 96-hour bioassay of white shrimp (*P. setiferus*) previously exposed to feed soaked in produced brine effluents.

PREVIOUS TREATMENT	BRINE EFFLUENT CONCENTRATION (ppm)	24 Hours		48 Hours		72 Hours		96 Hours	
		No. Shrimp	O_2 ppm	No. Shrimp	O_2 ppm	No. Shrimp	O_2 ppm	No. Shrimp	O_2 ppm
Regular Bioassay	0	19	1.98±0.41*	20	2.05±0.79*	19	2.76±1.09*	18	3.33±0.74*
	5000	10	2.40±0.83	8	1.92±0.72	8	3.01±0.69	6	3.00±0.74
Sea Water Soaked Feed	0	4	2.04±0.66	4	1.51±0.22	4	2.90±0.46	4	2.62±0.77
	5000	6	1.30±0.65	6	2.17±0.87	5	2.98±1.04	5	2.81±1.27
Effluent Soaked Feed	0	12	1.88±0.58	12	2.52±1.14	12	3.05±0.88	11	3.38±0.66
	5000	10	1.26±0.22	10	2.16±0.87	8	1.86±0.87	7	2.77±0.99

*Mean ± standard deviation.

TABLE 8. Relationship of molting mortality to number containers (beakers) produced brine effluent bioassays.

SAMPLE COLLECTION DATE	NUMBER OF SPECIMENS PER CONTAINER	NUMBER OF MOLTS	DEATHS AFTER MOLT	% MOLTING DEATHS
06/26/77	5	8	8	100
07/15/77	5	1	0	0
08/21/77	5	18	14	78
TOTAL		27	22	81
08/21/77	2	9	7	78
10/28/77	2	37	14	38
TOTAL		46	21	46
09/18/77	1[a]	21	2	10
09/18/77	1[a]	19	7	37
10/28/77	1	22	9	41
11/14/77	1	6	2	33
12/22/77	1	0	0	0
01/29/78	1	2	0	0
02/28/78	1	2	1	50
TOTAL		72	21	29

[a] Brown shrimp (*P. aztecus*)

TABLE 9. Percent survival (%) of penaeids (species combined) exposed to supernatant or whole effluent collected 06/26/77 and stored at room temperature.

DATE OF TEST		CONCENTRATION, ppm 1,000 %	 10,000 %
07/12/77	Mixed brine effluent	90	0
09/01/77	Mixed brine effluent	40	40
07/18/77	Supernatant	70	60
09/01/77	Supernatant	50	30

TABLE 10. Survival of penaeids (species combined) exposed to brine effluent or petroleum-treated produced brine effluent August 21, 1977.

UNTREATED

PRODUCTION PLATFORM	CONCENTRATION ppm	TIME TO 100% MORTALITY HOURS	96-HOUR SURVIVAL %
288-A	1,000	--	50
	10,000	>24 <44	0
296-B	1,000	--	46
	10,000	--	10

PETROLEUM-TREATED

PRODUCTION PLATFORM	CONCENTRATION ppm	TIME TO 100% MORTALITY HOURS	96-HOUR SURVIVAL %
288-A	1,000	--	30
	10,000	>12 <20	0
296-B	1,000	--	50
	10,000	> 2 <24	0

Work Unit 2.3.5 Determine Effects of Oil Field Discharges on Species Composition and Abundance of Pelagic Fishes and Demersal Fishes and Macro-Crustaceans in the Oil Field

Part A

NMFS/SEFC Galveston Laboratory

I. K. Workman
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ABSTRACT

A three-season study was made between the months of June 1977 and March 1978 to determine the effects of formation water discharge on the fishes and macro-crustaceans of the Buccaneer Oil Field (BOF)--an oil field located approximately 50 km offshore of Galveston, Texas. Quantitative and qualitative experimental results were obtained using diver observations and censuses, field bioassay experiments, underwater time-lapse photography, specimen collections with traps, trawls, hook and line, spears, and suction devices.

During the dye dispersion experiments,produced brine penetration in the waters under the production platforms was observed to be relatively shallow,averaging between 10 and 12 m in depth. The greatest concentration of the discharge was within the first 3 to 6 m of the surface. Current speed and direction controlled the dye distribution under the production platforms.

Results of field bioassay experiments indicate that the produced brine discharge by itself has no apparent effect on the blennies commonly found on the oil structures. Toxic effects,strong enough to kill the blennies, were observed when biocide was added to the produced brine discharge.

Seasonal changes in abundance, species composition and distribution were observed among the pelagic, reef and demersal fishes inhabiting the water under and around the oil field structures. The fishes and crustaceans were more abundant and a greater number of species was observed in the warm season (summer and fall) than in the cold season (winter). During the warm season,greater densities of pelagic/nektonic fishes were recorded under the the smaller control well jacket, while the reef fishes were more abundant on the larger production platform. In the winter,the fish populations were reduced to approximately equal densities under both structures. Fishes that normally inhabited the shallower water under the oil structures in the warmer season were found to have relocated to deeper depths in the cold season.

Red snapper (Lutjanus campechanus),a commercially and recreationally important fish, was determined through tagging studies to be structure faithful (a year-round resident of one oil structure). The study further showed that red snapper are the subject of heavy fishing pressure at the oil field structures.

Feeding habit studies suggest that the biofouling community on the structures are a possible food source for some of the fish species collected in the oil field.

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INTRODUCTION

In addition to the reef fishes, certain species of pelagic and demersal fishes and macro-crustaceans are frequently found in close association with natural and man-made reefs in the sea (Klima and Wickham 1971; Wickham et al. 1973; Shinn 1974; Wickham and Russel 1974; Hastings et al. 1976; Sonnier et al. 1976). A number of species attracted to reefs are commercially and recreationally important. The tendency of these species to congregate near oil field structures (man-made reefs) brings them into proximity of effluent discharges. The major effluent from production platforms is called produced brine or formation water. This is the water associated with oil and gas pools, and it is frequently produced along with oil and gas.

According to the Bureau of Land Management (1975),most formation water produced in the Gulf of Mexico is brine, characterized by an abundance of chlorides, mostly sodium chloride, and has concentrations of dissolved solids several times greater than that of sea water. The amount of mineral matter commonly found dissolved in oil field formation water ranges from a few parts per million (ppm)--nearly fresh water--to approximately 300,000 ppm--a heavy brine. In addition to the naturally occurring dissolved minerals, biocides are sometimes added to the formation water during the production process in an attempt to control the bacteria in the separator tanks. Before being discharged, the brine is passed through a "polishing" facility that removes all but traces (less than 50 ppm) of the entrained oil. The brine entering the sea is void of or very low in dissolved oxygen, it contains large quantities of dissolved minerals, and it may contain residual biocide.

The effects of produced brine effluent on pelagic, reef, and demersal fishes, and macro-crustaceans in the marine environment are not well understood. This study was conducted to improve this understanding. The objectives of this study were to determine or compare on a seasonal basis (1) the rates and patterns of effluent discharge dispersion from an oil and gas production platform, (2) the effects of effluent discharge on fishes associated with the platform, (3) the species composition, abundance, and distribution of fishes and macro-crustaceans under and around oil and gas field structures with and without discharges, (4) the movements of fishes among the structures of the field, and (5) the feeding habits of fishes associated with the oil and gas field.

MATERIALS AND METHODS

In November, 1978, produced brine (discharged from both production platforms 288-A and 296-B at the beginning of this study in August 1978) was directed to and discharged only from production platform 296-B (Figure 1). This caused a major change in the study by shifting emphasis in sampling from production platform 288-A (initially the only production platform being studied) to production platform 296-B. Some comparable sampling was continued on production platform 288-A through the remainder of the study year, but most of the sampling effort was diverted to production platform 296-B

The structure selected as a control was well jacket 288-5 (Figure 1). It continued to be used as a control throughout the year's study, but on two occasions an additional well jacket was used. Initially, well jacket 295-1 was to serve as a second control for trawl sampling. One sample tow was made there during the fall sampling period, but the structure was quickly abandoned as a control when the trawl net was lost (presumed to have snagged on one of the oil field pipelines) on a second sample tow. Well jacket 296-1 became the bioassay control during the winter sampling period. Well jacket 296-1 was selected because it was closer to the field station living quarters and therefore easier to get to and to observe during the harsher winter weather conditions. The use of the two additional well jackets as controls had no effect on the comparability of the data obtained during this year's study, except that it added one extra trawl sampling control station in the fall.

Distribution Patterns and Rates of Effluent Discharge

Distribution patterns and rates of produced brine discharge were observed by dye dispersion experiments conducted during all three seasons under the production platforms (288-A in summer, 296-B in fall and winter). During each season dye was injected into the discharge system, and, after 30 minutes of dye injection, divers made observations on the 12 major legs of the platform, recording (on hand-held slates) the depths of greatest oservable concentration and deepest dye penetration. In addition, current measurements were taken with a hand-held current meter, accurate to ±20 cm/second, and temperature measurements were made using diver wrist thermometers with an accuracy of $\pm 0.9^{\circ}$C. Summer and fall observations and measurements were taken at 2-hour intervals three times a sampling day. In the winter, only two observations were made with an hour interval between observations.

Effects of Effluent Discharge on Selected Blenny Species

During the fall and winter, field bioassay experiments were conducted to determine the effects of brine discharge. The crested blenny (*Hypleurochilus geminatus*) and the seaweed blenny (*Blennius marmoreus*) were selected as test subjects because of their common association with both production platforms and well jackets. Individuals of each species (30 to 40 each) were collected from well jacket 288-10 in the fall and winter (not directly influenced by brine discharge) and placed in two separate cages. One cage was attached to production platform 288-A in the fall and 296-B in the winter directly under the produced brine discharge, while the other cage was attached to a control structure (well jacket 288-5 in fall and well jacket 296-1 in winter). During the experiment, at irregular intervals, divers would make direct observations/inspections of the caged blennies. When dead blennies were observed, they were removed from the cage and preserved in 10% formalin. The experiments were terminated after approximately 2 days of exposure (45 hours in fall and 48 hours in winter). The live and dead blennies were removed from the cages, separated, and preserved in 10% formalin. All of the blennies were taken back to the laboratory for identification and sex determination.

Species Composition, Abundance, and Distribution

Underwater Time-lapse Photography

Under water time-lapse photography was used to measure species composition and relative abundance of each species in relation to type of structure and depth. The initial intent was to simultaneously compare the discharge and non-discharge sides of a production platform with one side of the control well jacket (same compass side as the discharge side of the production platform), but due to technical problems the cameras on the two opposite sides of the production platform never were operational at the same time. Comparable filming was completed under the production platform discharge side of 288-A in the summer and 296-B in the fall and winter and under the control well jacket 288-5 during all three seasons. Comparable filming was accomplished under production platform 288-A nondischarge side and under control well jacket 288-5 in the summer and fall.

The time-lapse camera systems were composed of three Minolta XL 400 Super-8 mm movie cameras contained in waterproof housings and interconnected by electrical cable to a housed intervalometer. Camera station depths on production platforms 288-A and 296-B (discharge and nondischarge sides) and control well jacket 288-5 were: 4.6 m, 12.2 m and 18.3 m (Figure 2). Each camera was mounted on a vertical member of the structure a measured distance away from (and pointed toward) an adjacent vertical member. The cameras were triggered by the intervalometers to film for a 1.5- to 2.0-second period every 5 to 7 minutes over a maximum time period of 9 hours and 40 minutes.

The film from each camera was analyzed in the laboratory, and the total number of fishes from each "burst" period was counted. Those fishes that could be identified by external morphological characteristics were recorded by species. All other fishes were recorded as unidentified.

Trap Sampling

A modified version of the sablefish trap (Hipkins, 1974) was used to obtain reference specimens and additional information on species composition and vertical distribution under the two structure types. During the summer, traps measuring 123 cm long by 87 cm square were fished at depths of: bottom(21.3 m), midwater(12.2 m) and near-surface(4.6 m) under the discharge side of production platform 288-A and control well jacket 288-5. In the fall and winter, only the bottom and midwater depth traps were fished under production platform 296-B and control well jacket 288-5. The traps were baited with dead fish caught in the oil field, suspended from the structures and fished for 17 to 24 hours each season.

Trap samples were frozen immediately after being removed from the water and returned to the laboratory for analysis.

Visual Census

Reef fishes (those fishes in close association with the structure members) and macro-crustaceans were visually censused by divers during the three sampling seasons on production platform 288-A in the summer and fall, 288-A and 296-B in the winter, and on control well jacket 288-5 all three seasons. Using sampling frames measuring 1 m x ½ m, at least two divers independently identified, counted and recorded on waterproof station sheets the fishes and macro-crustaceans observed on the selected structure legs.

Sampling stations were located 1.5 to 3.0 m below the surface, including eight stations (one on the discharge leg) on the production platform (Figure 3) and four stations on control well jacket 288-5 (one on each of the four major legs). In addition to the eight stations samples on production platform 296-B during the winter, three stations (including the discharge leg) were sampled, for a seasonal comparison, on production platform 288-A. The order of sampling and the sides of the structure members to be sampled were determined by random selection.

Airlift Sampling

An airlift suction sampler was used during the winter to help determine species composition, abundance and vertical distribution of the blennies (most abundant reef fishes) on production platform 296-B and control well jacket 288-5. The airlift sampler works like an underwater vacuum cleaner, sucking up all of the blennies within a sample station. The sample stations covered an area 1 m x ½ m and were located at depths of: 1.5-3.0 m (surface), 7.6 m (midwater) and 15.2 m (bottom) on the selected structure legs. On the production platform, the discharge leg and the leg directly opposite it (non-discharge side) were sampled, and on the control well jacket, a leg in the same position as that of the platform discharge leg was sampled. The station position in terms of compass direction on the leg was determined by random selection.

The blennies collected with the airlift sampler were preserved in 10% formalin and returned to the laboratory for analysis.

Trawl Sampling

Trawling was used to collect demersal fishes and macro-crustaceans around the two production platforms and control well jacket 288-5. Trawl samples were collected during the fall and winter using a 6.1 m trawl and towing for 5 minutes along the side of and as close as possible (30 m to 90 m) to the selected structures. During fall and winter seasons , four tows were made at one of the production platforms (288-A in fall, 295-B in winter), four tows were made at control well jacket 288-5, and two tows were made at the other production platform (296-B in fall, 288-A in winter). One additional tow was made in the fall at control well jacket 295-1. The order of sampling was random.

All trawl samples were immediately frozen, remaining frozen prior to and during transfer to Landry and Harper Consulting Service for analysis.

Selective Sampling

In addition to the methods already mentioned, selective specimen collections were made by spear, slurp gun, hook and line, and on most dives the divers tried to make visual observations. These methods were used to confirm species identification and to help evaluate the incidence of disease, feeding habits, condition factors, and areal movements of the fishes under the production platforms and well jackets. The diver observations present data not covered by the other methods employed in this study.

Fish Movements

Reward tags were used to determine inter-rig movements and residence times for selected commercially and recreationally important fish species (snapper and bluefish). The tags used were the same Floy dart tags as used in the BLM South Texas OCS snapper-grouper study (1977-1978) and the NMFS mackeral-bluefish study. (1977--). Fishes were captured on hook and line from the production platforms (288-A in summer and fall and 296-B in winter). Immediately upon capture, the fishes were measured for fork length, tagged with an appropriate dart tag and released at the site of capture.

Laboratory Processing

Formalin preserved sample collections and frozen sample collections were treated in essentially the same manner. The samples were sorted, and fish species were identified using keys by Gallaway et al. (1972), Walls (1975), and Hoese and Moore (1977). Individuals were measured for fork length to the nearest millimeter and wet-weighed to the nearest 0.1 g (wet weighted). Stomachs from each specimen were removed, placed in screw cap jars and preserved in 10% formalin.

Blenny sexes were determined by external dimorphic characters described by Hildebrand and Cable (1938).

All trawl sample collections and preserved stomachs were turned over to Landry and Harper Consulting Service for analysis (Part B).

Feeding Habits

Stomachs from 902 individuals of 20 different fish species were used to help determine the feeding habits of some of the more common fishes found under and around the oil structures. The majority of the fishes were collected by trawl. Additional samples were collected during trapping, hook-and-lining, spearing and other diving operations. Stomach content analysis of all of the samples was completed by Landry and Harper Consulting Service.

Data Analysis

Data generated by the preceding methods, requiring statistical analysis, were forward through NFEL to LGl Ecological Research Associates for final analysis (Part C).

RESULTS

Distribution Patterns and Rates of Effluent Discharge

The 3 days (August 17, 1977, November 11, 1977, and February 10, 1978) selected for studying effluent discharge all had similar current speeds and temperature conditions. The currents, although they flowed in a different direction during each study, were relatively weak and were not measurable with the hand-held current meter. Water temperature dropped significantly through the study year, but no thermal stratification (possible boundry for discharge dispersion) of the water column could be detected with the diver wrist thermometers during the dyed discharge studies.

During the summer, dye was injected into the formation water discharge of production platform 288-A for approximately 5 hours. The dyed discharge moved at approximately 100-200 cm/minute northward while under the platform, and was observed during the dives at between eight and nine of the 12 major legs (Figure 4). The discharge penetrated fairly rapidly to an average depth of 7.3 m and was observed as deep as 10 m at one leg. The maximum concentration of the dye was generally 1.5 to 4.6 m shallower than maximum penetration.

In the fall, dye was injected intermittently into the discharge of production platform 296-B to get a better estimate of the rate of discharge dispersion. During a 6-hour observation period, the dyed discharge was observed to move in a northeast to eastward direction at approximately 640 cm/minute as it spread laterally at approximately 370 cm/minute. On the three dives the dye was observed at between three and six of the 12 major legs (Figure 5). The deepest dye penetration was 12.8 m, while average penetration was 7.0 m. Maximum concentration averaged 4.5 m shallower than maximum penetration.

Dye was injected into the discharge of production platform 296-B for 2½ hours during the winter. The major portion of the dyed discharge moved west at about 460 cm/minute away from the production platform. Under the production platform, dye was observed only at the discharge leg (west side of platform). Diver observations out to a distance of 30 meters to the west of the production platform were attempted, but only one observation could be made before an oil rig stand-by boat tied off directly in front of the discharge and caused a change in its flow characteristics. On the one dive that was made to the west of the production platform, dye was observed to have penetrated to a 7.6 m depth 15 meters away and to a 9.1 m depth 30 meters away. The deepest depth at which the dye was observed on the discharge leg was 4.6 m, but the cloud of dye sloped off to approximately 7.6 m in the water immediately adjacent to the leg.

Effects of Effluent Discharge on Selected Blenny Species

In the fall field bioassay experiment (October 1977), 20 crested blennies and 15 seaweed blennies were caged beneath the discharge of production platform 288-A, and 26 crested blennies and 16 seaweed blennies were held in a cage under control well jacket 288-5. The exposure times were 45 hours for the production platform and 43 hours for the well jacket. The results of the experiment were negative (no mortality), but it was later learned that no biocide (normally present in the discharge) had been added to the production platform discharge process during the entire time of the experiment.

In February 1978 the experiment was repeated. A combination of 40 individuals of the two selected blenny species were placed in one cage and 39 individuals were placed in the other. The cage containing the 40 blennies was suspended under production platform 296-B and the cage with 39 blennies was suspended under control well jacket 296-1. The production platform cage was exposed to the effluent discharge for 48 hours, and the control cage was in the water for 44.5 hours. The experiment was terminated when a problem occurred with the attachment lines on the control cage. Initially, the control cage was attached so that it was free-riding on a drop line suspended from the structure, but on the last day of the experiment the lines became entangled, restricting the cage's movement and causing it to take an excessive battering from increasingly large waves.

During this experiment, a few unidentified blennies were lost from both cages. The five blennies missing from the control cage are thought to have been lost in a transfer just after the experiment. The reason for the loss of one blenny from the production platform cage is not known. At the end of the experiment the number of dead, live, and missing blennies were: production platform 296-B (20 seaweed and 3 crested blennies dead, 16 crested blennies alive and 1 blenny missing) and control well jacket 296-1 (3 crested blennies dead, 12 seaweed and 19 crested blennies alive and 5 blennies missing) (Table 1).

Species Composition, Abundance and Distribution

Underwater Time-lapse Photography

A total of 10 species of fish (Table 3) were identified from the time-lapse films taken over the three sampling seasons (Part C, Table 9).

Eight of these species were used for station abundance and diversity comparisons. Two other species, belted sandfish (Serranus subligarius) and cocoa damselfish (Pomacentrus variabilis), are reef fishes and were only recorded by cameras located close to other structure parts and, therefore, were not comparable to the other stations. A number of the fishes observed on the films were unidentifiable.

Atlantic spadefish (Chaetodipterus faber) and sheepshead (Archosargus probatocephalus) were present during all filming periods. Combined, these two species made up between 62% and 100% of the total number of fish species filmed, except during the late fall sampling (November 1977) when they made up only 3% of the identifiable fishes under control well jacket 288-5.

Average densities ranged from less than 0.001/m^3 on several occasions to almost 0.25/m^3 for pinfish (Lagodon rhomboides) on December 13, 1977 (Part C, Table 9). The greatest density and greatest number of species were filmed in November 1977. The summer (August 1977) and winter (February 1978) film samples contained approximately the same number of fish species, but density was greater in August 1977.

Larger concentrations of fishes were filmed under control well jacket 288-5 than under the production platforms in August 1977 (production platform 288-A) and November 1977 (production platforms 288-A and 296-B). This is best shown on the November 1977 time-lapse films when a greater number of fishes was filmed, and the concentrations were between 3 and 10 times greater under control well jacket 288-5 than under the production platforms (288-A and 296-B). In February 1978 fish density was greatly reduced, but, unlike the August 1977 and November 1977 film samples, more fishes were filmed under production platform 296-B than under control well jacket 288-5.

In August and November 1977, the fishes were more concentrated in the upper part of the water column (4.6 m and 12.2 m stations) on the production platforms and control well jacket 288-5, but in Feburary 1978 the major concentration of fishes shifted to below 12.2 m, This shift was confirmed by divers who observed the major concentration of fishes to be below the depth of the lowest camera station (18.3 m).

A large number of the fishes commonly found under or around the structures were never filmed, primarily because of their position in the water column. Divers observed and recorded 53 fish species that were seasonally present under the oil field structures (Table 3). Thirty-two of these were not captured or recorded by any of the other sampling methods used [illegible] his study.

Trap Sampling

The bottom traps captured fishes during all three seasons (Part C, Table 5) under control well jacket 288-5 and the production platforms (288-A in August 1977 and October 1977 and 296-B in February 1978). The mid-water (12.2 m) and near-surface (4.6 m) traps were only effective at capturing fishes in August 1977 under control well jacket 288-5. Trap catches were greater in August 1977 and more representative of the understructure species (comparing the number of species caught with the number of species observed by divers) than the October 1977 and Feburary 1978 catches. The number of fishes caught was greater under control well jacket 288-5 in August 1977 and February 1978 but greater under production platform 288-A in October 1977. Tomtate (*Haemulon aurolineatum*), red snapper (*Lutiamus campechanus*) and cabbyu (*Equetus umbrosus*) were the dominant species caught in August 1977; white spotted soapfish (*Rypticus maculatus*) and tomtate were dominant in October 1977 and red snapper and cubbyu were dominent in February 1978.

The tomtate caught in the August 1977 trap sampling under control well jacket 288-5 and production platform 288-A, and nine additional specimens caught on hook-and-line on the discharge side of production platform 288-A, were used to compare condition factors of the tomtate inhabiting the two different structure types. Using length-weight regression analysis to determine condition factor (LeCren 1951), essentially no differences could be found between the tomtate caught under control well jacket 288-5 and those caught under production platform 288-A (Figure 6).

Visual Census

The number of individuals and the species composition observed during the visual censuses on the structure legs of control well jacket 288-5 and production platform 288-A varied little between the August and October 1977 sampling months (Table 4). The blennies (crested and seaweed) predominated, making up between 69% and 87% of the total number of animals counted at each of the 12 census stations. During both August and October 1977, the average size of the blennies was smaller, but the number of individuals was higher on the discharge leg than on the other legs of production platform 288-A, and higher on production platform 288-A than on control well jacket 288-5.

Also consistently present in the summer and fall censuses, but not in the same abundance, were stone crabs (Menippi mercenaria) (8% to 22%) and cocoa damselfish(1% to 5%).

In February 1978 only the blennies and stone crabs remained at the visual census stations. The numbers of all three species at production platform 288-A and control well jacket 288-5 had been greatly reduced from the numbers observed in August and October 1977. The number of blennies on platform 288-A's non-discharge legs and control well jacket 288-5 legs decreased between 55% and 66%, while the number of blennies on production platform 288-A discharge leg decreased 76% from the numbers observed in August and October, 1977.

The data on Table 5 show that the number of blennies was higher on production platform 296-B than on production platform 288-A or control well jacket 288-5 during the February 1978 sampling. The visual census on production platform 296-B was conducted 19 days prior to the censuses on the other two structures. During that time there were several days of bad weather with seas as high as 15 to 20 ft observed in the oil field. It is suspected that if another census had been conducted on production platform 296-B after the bad weather the numbers might have been closer to those observed on production platform 288-A and control well jacket 288-5.

Because of their abundance, blennies were selected as a means of comparing condition factors between control well jacket 288-5 and production platform 288-A and between the two structures and the flare stack attached to production platform 288-A. During the summer, blennies were collected by spear from the discharge leg and the leg directly opposite it (non-discharge side) on production platform 288-A, from the legs of control well jacket 288-5 and from flare stack A. All of the samples were collected from the same depth range as the visual observations were made. The crested blenny was the only species collected from all but the discharge leg of production platform 288-A.

Of the 33 blennies collected from discharge leg A, four were crested blennies and the rest were seaweed blennies. The number of crested blennies collected from the other sites were: production platform 288-A non-discharge leg (77), control well jacket 288-5 (71), and flare stack A (33). The mean lengths and weights of the crested blennies collected at each station were: production platform 288-A discharge leg (57 mm and 3.59 g) non-discharge leg (64 mm and 5,33 g) control well jacket 288-5 (75 mm and 8.06 g) and flare stack A (75 mm and 7.57 g).

The length-weight analyses performed by LGL Ecological Research Associates indicated that there were no significant differences between the blennies collected at any of the four collection sites (Part C, Tables 11-13).

Airlift Sampling

The airlift sample collection data were comparable with the results obtained from the February 1978 visual census sampling (Table 6). The number of blennies captured at the near surface stations on control well jacket 288-5 and production platform 296-B were closely comparable with the February 1978 visual counts made at the same depths on control well jacket 288-5 and production platform 288-A. The differences in the numbers of blennies visually censused during February 1978 on production platform 296-B, versus the number of blennies caught at the shallower air-lift stations on that structure, is a further indication that the differences in the visual counts on production platform 288-A and 296-B were probably the results of the bad weather experienced between the censuses.

The number of blennies captured on production platform 296-B increased (2 to 8 fold) with depth between the near-surface and the 7.6 m stations, while the number of blennies caught reduced by half between the same stations on control well jacket 288-5. There was a general decrease in the number of blennies caught on both structures with the increase in depth between the 7.6 m and the 15.2 m stations. The decrease was less pronounced on control well jacket 288-5 than on production platform 296-B where there was a 9% to 30% reduction in number between the 7.6 m and the 15.2 m stations. Below the 15.2 m stations, because of the lack of suitable habitat, there are essentially no blennies on control well jacket 288-5 or production platform 296-B.

Crested blennies were the dominant species at the near-surface and the 7.6 m stations. Seaweed blennies replaced crested blennies as the dominant species at the 15.2 m stations.

Both blenny species collected from control well jacket 288-5 had a larger average size (near-surface and 7.6 m stations) than those collected from production platform 296-B. At all of the eight stations from which both species of blenny were caught, the seaweed blenny was generally larger.

Trawl Sampling

A total of 38 species of demersal fish and 23 species of macro-crustaceans were collected in the October 1977 and March 1978 trawl samples (Table 7). The October 1977 samples contained 18 fish species and 17 species of macro-crustaceans (Table 8), while March 1978 samples contained 18 fish species and 16 species of macro-crustaceans (Table 9). There were 11 species of fish and 10 species of macro-crustaceans common to both sampling seasons (Table 10).

The number of demersal fish species and abundance appeared to be greater during both trawl seasons around production platform 288-A. The exception to this was in October 1977 when six more demersal fish species were collected around control well jacket 288-5 then around platform 288-A. The number of species of macro-crustaceans caught in October 1977 was approximately equal at all of the stations, but numbers of individuals were greater around production platform 296-B and control well jacket 295-1. In March 1978 the number of crustacean species and abundance appeared to be greater around control well jacket 288-5.

The dominant demersal fish species caught in the fall were: sea catfish (Arius felis),. shoal flounder (Syacium gunteri), and red snapper, and the dominant crustcean species was brown shrimp (Penaeus aztecus). In the winter, shoal flounder was the only dominant fish species, and sugar shrimp (Trachypenaeus similis) replaced brown shrimp as the dominant macro-crustacean.

Fish Movements

A total of 38 red snapper and 30 blue fish were tagged and released during this year's study. The major portion of these (29 red snapper and 28 blue fish) were tagged and released in January, February and March, 1978 from production platform 296-B. Ten of the tags used on red snapper during the three months tagging effort (34% of the total number of red snapper released in January, February and March 1978) have been returned (Table 11). No tags have been returned from the August 1977 or November 1977 releases. All 10 recaptured fish were caught at production platform 296-B where they were earlier released.

The number of days between release and recapture ranged from 19 to 150 days. The methods of recapture and the number of fish recaptured by each method were: rod and reel (9) and diver spear (1). It is possible that more tags will be returned in the future.

Feeding Habits

Stomach contents data were summarized by LGL Ecological Research Associates in Part C, Tables 14-40. From this summarization,eight of the 20 species examined were set apart, on the basis of examined stomachs containing some form of algae, as being possible rig grazers (grazers on oil structures). The eight species included: Bermuda chub (Kyphosus sectatrix), yellow chub (Kyphosus incisor), crested blenny, seaweed blenny, sheepshead, atlantic spadefish, tomate and sea catfish. All of these species are seasonally common members of the under-structure fish community except sea catfish which is a transient under-structure species.

DISCUSSION

The study of the formation water discharge shows that maximum dye penetration under the production platforms is relatively shallow. If it is assumed that the dye completely colors the discharge, then the direct effects of the formation water, even under the calmest current conditions, do not extend much below 10 or 12 m. Under both production platforms, the primary area affected by the discharge is in the first 3 to 6 m of the water column. Increased current speeds have a shearing effect on the discharge coverage (spread and penetration). Current direction also controls discharge coverage under the platform. Maximum coverage under a discharging platform occurs when the current is flowing in a north to northeast direction. Discharge coverage under the platforms is minimal when the current is flowing in a westerly directon (northwest to southwest).

The short-term field bioassay experiments give an indication of the immediate effects of the formation water discharge. Data indicate that toxic effects, strong enough to kill small reef fishes, are only exhibited when biocide is added to the formation water. The entrained oil and dissolved minerals by themselves did not have an immediate effect on crested or seaweed blennies. Comparing these findings with the observed diluting action as the brine enters the water under the discharging platform (dyed discharge study) and with the fact that blennies do inhabit the shallower parts of the discharge leg (exposed to the discharge) give reason to believe that the immediate effects of the brine discharge are not felt much beyond the point of entry.

Seasonal trends in abundance and species composition of the larger pelagic/nektonic fishes were obtained from underwater time-lapse photography and diver observations. These trends or changes were similar to those observed by Hashings et al. (1976) on two research structures (non-petroleum) in the northeastern Gulf of Mexico. They depicted two distinctly different seasons--summer (which included summer and fall) and winter. These two distinct seasons were also observed during this study.

In both studies,species diversity and abundance were observed to be greatest in the warm season (not varying much between summer and fall) and lowest in the cold season. These changes, as suggested by Hasting et al. (1976), were the result of the extreme temperature drop experienced in the cold season (from a high of 30°C in August 1977 to a low of 10°C in January 1978 in the BOF). Apparently the fishes either move to warmer or to deeper, more temperature stable,waters as water temperature drops. Movements to deeper depths under the structures were observed by divers during the cold season.

Diver observations and time-lapse films showed sheepshead and atlantic spadefish to be the most commonly abundant pelagic/nektonic fishes under both structure types. Apparently these two species are year-round residents of the oil field.

The greater numbers of fishes observed on the time-lapse films taken under the control well jacket during the warm season are thought to be the result of the concentrating effect of a smaller structure. The concentrating effect caused by the closeness of the structure members on the smaller structures would give the effect of more fishes inhabiting the well jackets than the production platforms.

At no time was there any indication that the brine discharge from either production platform had any discernable effects on the pelagic/nektonic fishes. Divers often observed these fishes (during the dyed discharge study) swimming in the brine discharge with no apparent effect.

The traps did not prove to be an effective sampling method except during the August 1977 sampling period. At that time a large number of fish were caught under both control well jacket 288-5 (77) and production platform 288-A (34). These catches indicate that the fishes were more concentrated under control well jacket 288-5.

The October 1977 and February 1978 trap samples were helpful in determining that red snapper is a permanent resident under control well jacket 288-5 and under production platforms 288-A and 296-B.

The reef fishes and macro-crustaceans inhabiting the structure members of control well jacket 288-5 and production platforms 288-A and 296-B exhibited the same species composition and the same changes in composition during the two distinct seasons referred to earlier. The crested blenny was the dominant reef fish species observed (visual census) and collected (spearing and airlift sampling) at almost all of the visual census and collection sites on control well jacket 288-5 and production platforms 288-A and 296-B, except on the discharge leg of production platform 288-A in August 1977 and at the 15.2m airlift stations where the seaweed blenny was the dominant species.

During the warm season there were more blennies counted on the discharge leg than on any other leg on production platform 288-A and more on production platform 288-A than on control well jacket 288-5. The reverse was true for the size of the blennies. The blennies collected from production platform 288-A were smaller than those collected from control well jacket 288-5, and the blennies collected from the discharge leg of production platform 288-A were smaller than those collected on the non-discharge legs of that platform.

Stone crabs were the only other permanent inhabitant counted at the visual census stations. Stone crabs and the two blenny species were greatly reduced in number by the winter weather conditions.

The data obtained from the August 1977 and October 1977 visual censuses and the blenny collections made by spear and airlift sampler indicate that the brine discharge has some effect on the structure member inhabitants of the production platforms. The data do not clearly show if this is a direct effect or a secondary effect. The differences in the sizes and the numbers of blennies observed may have been the result of the toxic effects of the brine discharge (as shown in the bioassay study) or they may be a result of habitat limitations. Habitat differences became apparent during a comparison of dead barnacles made between the discharge leg and a non-discharge leg on production platform 288-A. In this comparison, there were twice as many dead barnacles (possibly the result of brine discharge) counted on the discharge leg, and the barnacles were smaller than those counted on the non-discharge leg. This helps to explain the smaller blennies collected on the discharge leg because blennies occupy the dead barnacle shells and they tend to select barnacle shells of a similar size to themselves. The difference in dominant blenny species is probably a secondary effect since the seaweed blenny (dominant species on production platform 288-A discharge leg) was the most susceptible of the two species of blennies to the effects of the brine discharge.

The two fish species (crested blenny and Tomtate) used to compare condition factors between control well jacket 288-5 and production platform 288-A were selected because they were found to be common and abundant under both of the structures. The fact that no significant differences could be found between any of the tested length-weight relationships is a further indication that the fishes under the production platforms are probably not directly affected by the discharge.

Some differences were observed in the number and distribution of the demersal fishes and macro-crustaceans on the bottom immediately adjacent to the structures, but because of the bottom depth and the results of the dyed discharge study these differences are not believed to be the result of formation water discharge. A look at the geographic distribution of sediments in the Buccaneer Oil Field (Anderson et al. 1977) indicate the differences observed in the trawl collections are probably due to differences in bottom sediment types.

The limited data obtained on fish movements indicate that red snapper is structure faithful. After recruitment, this fish spends the remainder of its life cycle under the same structure (indicated by the length of time between tagging and recapture). The number of tags returned indicates that their life expectancy once under an oil structure is fairly short as a result of fishing pressure. Fishing pressure in the BOF has been documented as being heavy in other studies (Trent et al. 1977 and Ditton and Graefe 1978) in which red snapper was found to be the primary target species of the recreational fisherman.

The fishes used for stomach content analysis included pelagic, reef and demersal fishes seasonally common in the BOF. Of the 20 species examined, eight were determined to be possible grazers on the oil structures.

CONCLUSIONS

1. The rates and patterns of formation water discharge dispersion from the production platforms are directly dependent upon current speed and direction. The depths of maximum discharge penetration and concentration were observed to be relatively shallow under the production platforms throughout the study year.

2. Toxic effects strong enough to kill small reef fishes were only exhibited when biocide was added to the formation water. These effects appeared to be limited to the area immediately under the discharge. Habitat limitations created by the discharge also had an effect on the size and composition of the reef fishes inhabiting the discharge leg of production platform 288-A.

3. The pelagic, reef and demersal fishes and macro-crustaceans of the oil field all underwent seasonal changes in species composition, abundance and distribution comparable with other parts of the northern Gulf of Mexico. Abundance and diversity were greater in the warm season than in the cold season.

4. Red snapper is a structure faithful fish which may be the subject of overfishing while under the oil field structures.

5. Stomach content analyses suggest that some of the fishes found under and around the oil field structures may derive some of their food from the attached plant life on those structures.

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APPENDIX

Table 1. Field bioassay in winter

Exposure	Method of inspection[a]	Treatment 40 individuals[b]		Control 39 individuals[c]	
		Dead	Alive	Dead	Alive
20 hrs 55 min	Visual			None observed	
22 hrs 15 min	Visual	Dead observed			
23 hrs 15 min	Sampled	9 #2			
26 hrs	Visual			None observed	
27 hrs 15 min	Visual	Dead observed			
28 hrs 15 min	Sampled	1 #1 3 #2			
43 hrs 15 min	Visual	Dead observed			
43 hrs 30 min	Visual			Dead observed	
44 hrs 30 min	Sampled			3 #1 0 #2	19 #1 12 #2
47 hrs 45 min	Sampled	2 #1 8 #2	16 #1 0 #2		
Total dead at end of experiment		3 #1 20 #2	16 #1 0 #2	3 #1 0 #2	19 #1 12 #2

Species #1 = Hypleurochilus geminatus

Species #2 = Blennies marmoreus

[a] Visual = diver observations
Samples = dead blennies removed

[b] 1 individual missing at end of experiment

[c] 5 individuals missing at end of experiment

Table 2. Species observed by time-lapse photography

	Scientific Name	Common name	Sampling season observed*
1.	Serranus subligarius	Belted sandfish	S
2.	Caranx crysos	Blue runner	S,F
3.	Vomer setapinnis	Atlantic moonfish	S
4.	Haemulon aurolineatum	Tomtate	F
5.	Archosargus probatocephalus	Sheepshead	S,F,W
6.	Lagodon rhomboides	Pinfish	F
7.	Chaetodipterus faber	Atlantic spadefish	S,F,W
8.	Pomacentrus variabilis	Cocoa damselfish	S
9.	Balistes capriscus	Gray triggerfish	F
10.	Sphyraena barracuda	Great barracuda	S

*S = Summer 1977
F = Fall 1977
W = Winter 1978

Table 3. Fish species observed by divers in the Buccaneer Oil Field with an indication of seasonal abundance

Species	Abundance[2]			Structure[3]
	Summer	Fall	Winter	
Sphyrna sp.[1] (Hammerhead shark)	O	O	-	A
Sardinella anchovia[1] (Spanish sardine)	O	-	-	A,C
Harengula pensacolae[1] (Scaled sardine)	-	O	-	A
Opsanus beta (Gulf toadfish)	-	R	R	A,B
Holocentrus ascensionis[1] (Squirrel fish)	R	R	-	A
Serranus subligarius (Belted sandfish)	C	C	O	A,B,C
Centropristis philadelphica (Rock sea bass)	R	-	-	C
Mycteroperca phenax[1] (Scamp)	O	O	O	A,B,C
Rypticus maculatus (Whitespotted soapfish)	C	C	O	A,B,C
Priacanthus arenatus[1] (Bigeye)	C	C	R	A,B,C
Pomatomus saltatrix (Bluefish)	C	C	C	A,B,C
Rachycentron canadum[1] (Cobia)	O	R	-	A,C
Echeneis naucrates[1] (Sharsucker)	O	O	-	A,C
Elagatis bipinnulata[1] (Rainbow runner)	O	O	-	A,C
Seriola dumerili[1] (Greater amberjack)	O	O	R	A,B,C
Seriola zonata[1] (Banded rudderfish)	R	-	-	A
Vomer setapinnis (Atlantic moonfish)	C	C	-	A,C
Selene vomer[1] (Look down)	C	C	-	A,C

Table 3 (Continued)

Species	Abundance[2] Summer	Fall	Winter	Structure[3]
Decapterus punctatus[1] (Round scad)	O	-	-	A,C
Caranx ruber[1] (Bar jack)	R	-	-	A
Caranx crysos (Blue runner)	C	C	-	A,C
Caranx hippos[1] (Crevalle jack)	-	R	-	C
Lutjanus synagris (Lane snapper)	O	-	-	A
Lutjanus campechanus (Red snapper)	C	C	C	A,B,C
Lutjanus griseus[1] (Gray snapper)	R	-	-	A,B
Lobotus surinamensis[1] (Tripletail)	R	-	-	O
Haemulon aurolineatum (Tomtate)	C	C	C	A,B,C
Orthopristis chrysoptera (Pigfish)	C	C	C	A,B,C
Lagodon rhomboides (Pinfish)	C	C	O	A,B,C
Archosargus probatocephalus (Sheepshead)	C	C	C	A,B,C
Sciaenops ocellata[1] (Red drum)	-	-	R	B
Equetus umbrosus (Cubbyu)	C	C	C	A,B,C
Kyphosus sectatrix[1] (Bermuda chub)	C	O	-	A,C
Kyphosus incisor[1] (Yellow chub)	C	O	-	A,C
Chaetodipterus faber (Atlantic spadefish)	C	C	C	A,B,C
Holocentrus bermudensis (Blue angelfish)	R	-	-	O
Chaetodon ocellatus (Spotfin butterflyfish)	O	O	R	A,B,C

Table 3 (Continued)

Species	Abundance[2]			Structure[3]
	Summer	Fall	Winter	
Chaetodon striatus (Banded butterflyfish)	R	-	-	A
Pomacentrus variabilis (Cocoa damselfish)	C	C	R	A,B,C
Abundefdur saxatilis[1] (Sergeant major)	C	C	-	A,B,C
Chromis multilineata[1] (Brown chromis)	R	-	-	A
Halichoeres caudalis[1] (Painted wrasse)	O	O	R	A,C
Sphyraena barracuda (Great Barracuda)	O	R	-	A,C
Blennius cristatus[1] (Molly miller)	O	O	-	A
Blennius marmoreus (Seaweed blenny)	C	C	C	A,B,C
Hypleurochilus geminatus (Crested blenny)	C	C	C	A,B,C
Scomberomorus sp.[1] (Mackerel)	R	-	-	A,C
Scorpaena plumieri[1] (Spotted scorpionfish)	C	C	-	A
Paralichthys albigutta[1] (Gulf flounder)	O	-	-	C
Balistes vetula[1] (Queen triggerfish)	R	R	-	A,C
Balistes capriscus (Gray triggerfish)	C	C	-	A,B,C
Aluterus scriptus[1] (Scrawled filefish)	R	-	-	A
Monocanthus hispidus[1] (Planehead filefish)	O	R	-	A

[1] Unrecorded by any sampling method employed in this study

[2] Abundance index C = common, O = occasional, R = rare

[3] Structure observed at A = production platform 288-A, B = production platform 296-B, C = control well jacket 288-5, O = other well jackets

Table 4. Summer and fall visual censuses (average number/m^2)

Species	Summer			Fall		
	Platform 288-A		Well Jacket 288-A	Platform 288-A		Well Jacket 288-5
	Discharge Leg	Other Legs		Discharge Leg	Other Legs	
Blennies	58.00	37.09	31.38	52.00	40.28	32.25
Cocoa damselfish *Pomocentrus variabilis*	3.67	2.67	0.25	0.50	4.86	0.25
Belted sandfish *Serranus subligaris*		0.38	2.00		0.29	2.25
Sheepshead *Archosargus probatocephalus*	1.33	1.05	0.80		0.29	
Sergeant major *Abudefduf saxtilis*			0.17	1.50	0.43	
Greater soapfish *Rypticus maculatus*	0.05					
Stone crab *Menippi mercenaria*	5.67	8.71	6.75	7.50	13.00	8.00
Blue crab *Callinectes sapidus*		0.14				

Table 5. Winter visual census (average number/m^2)

Species	Winter				
	Platform 288-A		Platform 288-B*		Well Jacket 288-5
	Discharge Leg	Other Legs**	Discharge Leg	Other Legs**	
Blennies	13	17	28	30.28	11.26
Stone crab *Mennippi mercenaria*		3	4	1.58	1.26

[*] Sampled 19 days before other structures

[**] Only two other legs sampled

Table 6. Blenny samples collected by air-lift suction pump

Structure	Station depth (meters)	Species	Number	Mean length (mm)	Mean weight (g)	Sex ratio M : F
CONTROL WELL JACKET 288-5	1.5-3.0	Crested blenny	10	56.10	3.53	4 : 6
		Seaweed blenny	1	72.00	4.91	0 : 1
	7.6	Crested blenny	4	50.25	3.63	2 : 2
		Seaweed blenny	2	78.00	6.38	1 : 1
	15.2	Crested blenny	2	38.50	1.33	1 : 1
		Seaweed blenny	2	28.00	0.56	0 : 2
PLATFORM 296-B DISCHARGE	1.5-3.0	Crested blenny	9	54.56	2.99	7 : 2
		Seaweed blenny	1	69.00	3.52	1 : 0
	7.6	Crested blenny	17	40.41	1.34	2 : 15
		Seaweed blenny	5	63.60	3.38	4 : 1
	15.2	Crested blenny	1	30.00	0.40	0 : 1
		Seaweed blenny	1	55.00	2.03	0 : 1
PLATFORM 296-B NON DISCHARGE	1.5-3.0	Crested blenny	4	49.25	2.19	3 : 1
		Seaweed blenny	-	-	-	-
	7.6	Crested blenny	22	51.91	2.36	12 : 10
		Seaweed blenny	11	47.27	1.89	3 : 8
	15.2	Crested blenny	3	40.00	1.06	0 : 3
		Seaweed blenny	7	61.43	2.98	4 : 3

Table 7. Species observed in trawl samples

	Scientific Name	Common Name
	Finfishes	
1.	*Raja texana*	Roundel skate
2.	*Ophichthus gomesi*	Shrimp eel
3.	*Synodus foetens*	Inshore lizardfish
4.	*Arius felis*	Sea catfish
5.	*Porichthys porosissimus*	Atlantic midshipman
6.	*Halieutichthys aculeatus*	Pancake batfish
7.	*Ogcocephalus parvus*	Roughback batfish
8.	*Urophycis floridanus*	Southern hake
9.	*Lepophidium graellsi*	Blackedge cusk-eel
10.	*Centropristis philadelphica*	Rock sea bass
11.	*Diplectrum bivittatum*	Dwarf sand perch
12.	*Lutjanus campechanus*	Red snapper
13.	*Lutjanus synagris*	Lane snapper
14.	*Eucinostomus argenteus*	Spotfin mojarra
15.	*Haemulon aurolineatum*	Tomtate
16.	*Orthopristis chrysoptera*	Pigfish
17.	*Lagodon rhomboides*	Pinfish
18.	*Stenotomus caprinus*	Longspine porgy
19.	*Cynoscion arenarius*	Sand seatrout
20.	*Cynoscion nothus*	Silver seatrout
21.	*Equetus umbrosus*	Cubbyu
22.	*Micropogon undulatus*	Atlantic croaker
23.	*Pogonias cromis*	Black drum
24.	*Chaetodipterus faber*	Atlantic spadefish
24.	*Polydactylus octonemus*	Atlantic threadfin
26.	*Peprilus alepidotus*	Harvestfish
27.	*Scorpaena calcarata*	Smoothhead scorpionfish
28.	*Prionotus ophryas*	Bandtail searobin
29.	*Prionotus roseus*	Bluespotted searobin
30.	*Prionotus rubio*	Blackfin searobin

Table 7 (Continued)

	Scientific Name	Common Name
	Finfishes (Continued)	
31.	Ancylopsetta quadrocellata	Ocellated flounder
32.	Citharichthys spilopterus	Bay whiff
33.	Cyclopsetta chittendeni	Mexican flounder
34.	Etropus crossotus	Fringed flounder
35.	Syacium gunteri	Shoal flounder
36.	Gymnachirus texas	Fringed sole
37.	Symphurus plagiusa	Blackcheek tonguefish
38.	Sphoeroides parvus	Least puffer
	Macro-Crustaceans	
1.	Squilla empusa	Mantis shrimp
2.	Penaeus aztecus	Brown shrimp
3.	Trachypeneus similis	Sugar shrimp
4.	Sicyonia brevirostris	Rock shrimp
5.	Sicyonia typica	Shrimp
6.	Sicyonia dorsalis	Chevron rock shrimp
7.	Sicyonia stimpsoni	Shrimp
8.	Family Paguridae	Unidentified
9.	Petrochirus diogenes	Hermit crab
10.	Pagurus impressus	Hermit crab
11.	Petrolisthes armatus	Crab
12.	Porcellana sayana	Porcelain crab
13.	Calappa sulcata	Box crab
14.	Hepatus epheliticus	Calico crab
15.	Portunus spinimanus	Swimming crab
16.	Callinectes sapidus	Blue crab
17.	Callinectes similis	Pigmy blue crab
18.	Menippi mercenaria	Stone crab
19.	Hexapanopeus paulensis	Crab
20.	Glyptoxanthus erosus	Mud crab
21.	Podochela sydneyi	Crab

Table 7 (Continued)

	Scientific Name	Common Name
	Macro-Crustaceans (Continued)	
22.	Libinia dubia	Spider crab
23.	Parthenope serrata	Crab
	Other Invertebrates	
1.	Order Actinaria	
2.	Cailliactis tricolor	Sea anemone
3.	Cupuladria canariensis	
4.	Architectonica nobilis	Sundial shell
5.	Distorsio clathrata	Writing shell
6.	Murex fulvescens	Tawny murex
7.	Cantharus cancellaria	Cross-barred spindle
8.	Busycon perversum	Lightning conch
9.	Fasciolaria illium	Tulip shell
10.	Pleuroploca gigantea	Florida horse conch
11.	Anadora transversa	Traverse ark
12.	Arca sp.	Ark
13.	Noetia ponderosa	Ponderous ark
14.	Lolliguncula brevis	White squid
15.	Astropectinidae	Scallop
16.	Astropecten sp.	Scallop
17.	Ophiolepis pancispina	Brittle star
18.	Chloeia viridis	Anemone

Table 8. Trawl catches of demersal fishes and macro-crustaceans in fall

Demersal Fishes	Station Platform 288-A 1 N	 2 E	 3 S	 4 W	 Control 288-5 5 N	 6 E	 7 S	 8 W	 Platform 296-B 9 N	 11 S	 Control 295-1 15 S	Total
Raja texana				1								1
Synodus foetens					1		1					2
Arius felis	125	33	20	80	10	7	6	21	16	7		325
Porichthys porosissimus					1	1	1				1	4
Halieutichthys aculeatus	2				3		4	1	2		1	13
Ogcocephalus parvus	2	1						1	1		1	6
Centropristis philadelphica	1					1	1					3
Diplectrum bivittatum					2	1	4		1	1		9
Lutjanus campechanus	1	3	2			1	5	1	1	5	8	27
Lutjanus synagris				1		1		1			1	4
Eucinostomus/ argenteus			1		1							2
Haemulon aurolineatum	1	1				6					4	12
Orthopristis chrysoptera	1	1	1			1						4
Lagodon rhomboides						1						1
Stenotomus caprinus							1		1		1	3
Cynoscion arenarius		3						1			1	5

Table 8 (Continued)

	Station											
	Platform 288-A				Control 288-5				Platform 296-B		Control 295-1	
Demersal fishes	1 N	2 E	3 S	4 W	5 N	6 E	7 S	8 W	9 N	11 S	15 S	Total
Cynoscion nothus				1								1
Equetus umbrosus	2	1				5					1	9
Micropogon undulatus	1								7		17	25
Pogonias cromis						1						1
Chaetodipterus faber						4						4
Polydactylus octonemus											1	1
Scorpaena calcarata								1				1
Prionotus ophryas									1			1
Prionotus roseus	1				2		1				2	6
Ancylopsetta quadrocellata									1			1
Citharichthys spilopterus				3		1						4
Cyclopsetta chittendeni									1			1
Etropus crossotus						1						1
Syacium gunteri	9			5	13	10	18	7	11	3	6	82
Gymnachlrus texae	1											1

Table 8 (Continued)

	Station											
	Platform 288-A				Control 288-5				Platform 296-B		Control 295-1	
Demersal fishes	1 N	2 E	3 S	4 W	5 N	6 E	7 S	8 W	9 N	11 S	15 S	Total
Symphurus plaguisa								1			1	2
Sphoeroides parvus										2		2
Total by station	147	42	25	91	33	42	42	35	43	18	46	564
Macro-Crustaceans												
Penaeus aztecus	5		1	1	3	4	10	5	13		11	53
Trachypenaeus similis	1		1		1	1	9	1	1		12	27
Sicyonia typica					1			1		1	1	4
Sicyonia dorsalis					3	2	5				3	13
Petrochirus diogenes	1	1		3	2	3		2	3			15
Pagurus impressive	1	1				1						3
Petrolisthes armatus									1			1
Porcellana sayana					1							1
Hepatus epheliticus	1			4	2	1	1	2	14		3	28
Calappa sulcata							1			1	1	3
Portunus spinimanus				1	1	1	4	2	6		5	20
Callinectes sapidus									1		2	3
Callinectes similis					2	1	5		2			10

Table 8 (Continued)

	Station											
	Platform 288-A				Control 288-5				Platform 296-B		Control 295-1	
Macro-Crustaceans	1 N	2 E	3 S	4 W	5 N	6 E	7 S	8 W	9 N	11 S	15 S	Total
enippe mercenaria		1		1					1			3
exapanopeus paulensis				1								1
lyptoxanthus erosus				1								1
arthenope serrata				1							1	2
otal by station	9	3	2	13	16	14	35	13	42	3	37	187

Table 9. Trawl catches of demersal fishes and macro-crustaceans in winter

Fish Species	Station										Total
	Platform 296-B				Platform 288-A		Control 288-5				
	1 S	2 W	3 N	4 E	5 S	7 N	9 S	10 W	11 N	12 E	
Ophichthus gomesi			1								1
Halieutichthys aculeatus					1						1
Ogcocephalus parvus				2	4		2	1		2	11
Urophycis floridanus	1	1	1			2			1	1	7
Lepophidium graellsi						1		2			3
Centropristis philadelphica						1			1	1	3
Diplectrum bivittatum				1		1	1			1	4
Lutjanus campechanus	3				1						4
Orthopristis chrysoptera	1				4		1	2	3		11
Lagodon rhomboides						1					1
Equetus umbrosus					1						1
Peprilus alepidotus			1								1
Scorpaena calcarata	1					1				2	4
Prionotus ophryas						1					1
Prionotus rubio			1	1		1		1			4
Etropus crossotus		1	1					1			3
Syacium gunteri	4	11	4	5	2	6	14	17	13	16	92
Symphurus plagiusa					1	1		1	2		5
Total by station	10	13	9	9	14	16	18	25	20	23	157
Macro-crustacean Species											
Squilla empusa		1	1		2		2	2			8
Penaeus aztecus			1					2	1		4
Trachypenaeus similis		10	3			6	2	12	3	3	39

Table 9 (Continued)

	Station										
	Platform 296-B				Platform 288-A		Control 288-5				
Macro-crustacean Species	1 S	2 W	3 N	4 E	5 S	7 N	9 S	10 W	11 N	12 E	Total
Sicyonia brevirostris									1		1
Sicyonia typica							2				2
Sicyonia dorsalis			1			5		2		1	9
Sicyonia stimpsoni		1						1	1		3
Petrochirus diogenes			1	1		1		4	1	2	10
Family Paguridae					1						1
Pagurus impressus						2		1	1		4
Petrolisthes armatus						1				33	34
Porcellana sayana								6	1		7
Portunus spinimanus						1		2			3
Parthenope serrata									1		1
Podochela sydneyi		2					2		3	1	8
Libinia dubia		1									1
Total by station	0	15	7	1	3	16	8	32	13	40	135

Table 10. Demersal fishes and macro-crustaceans common to both trawl seasons

Scientific Name	Common Name
Finfishes	
Ogcocephalus parvus	Roughback batfish
Centropristis philadelphica	Rock sea bass
Diplectrum bivittatum	Dwarf sand perch
Lutjanus campechanus	Red snapper
Orthopristis chrysoptera	Pigfish
Lagodon rhomboides	Pinfish
Equetus umbrosus	Cubbyu
Prionotus ophryas	Bandtail searobin
Stropus crossotus	Fringed flounder
Syacium gunteri	Shoal flounder
Symphurus plagiusa	Blackcheek tonguefish
Macro-Crustaceans	
Penaeus aztecus	Brown shrimp
Trachypenaeus similis	Sugar shrimp
Sicyonia typica	Shrimp
Sicyonia dorsalis	Chevron rock shrimp
Petrochirus diogenes	Hermit crab
Pagurus impressus	Hermit crab
Petrolisthes armatus	Crab
Porcellana sayana	Porcelain crab
Portunus spinimanus	Swimming crab
Parthenope serrata	Crab

Table 11. Number of *Lutjanus campechanus* tagged and recaptured

Tag No.	Date tagged	Station	Date Recaptured	Station
13013	8-19-77	Production Platform 288-A	-	-
13014	8-19-77	Production Platform 288-A	-	-
13015	8-19-77	Production Platform 288-A	-	-
13016	8-19-77	Production Platform 288-A	-	-
12017	8-19-77	Production Platform 288-A	-	-
13018	8-19-77	Production Platform 288-A	-	-
13019	8-19-77	Production Platform 288-A	-	-
13021	11-12-77	Production Platform 288-A	-	-
13022	1-27-78	Production Platform 296-B	-	-
13023	1-27-78	Production Platform 296-B	-	-
13025	1-27-78	Production Platform 296-B	3-27-78	Production Platform 296-B
13027	1-27-78	Production Platform 296-B	-	-
13028	1-29-78	Production Platform 296-B	-	-
13029	1-29-78	Production Platform 296-B	3-31-78	Production Platform 296-B
13030	1-29-78	Production Platform 296-B	-	-
13031	1-29-78	Production Platform 296-B	Date not available	Production Platform 296-B
13032	1-29-78	Production Platform 296-B	3-18-78	Production Platform 296-B
13033	1-29-78	Production Platform 296-B	-	-
13034	1-29-78	Production Platform 296-B	3-9-78	Production Platform 296-B

Table 11 (Continued)

Tag No.	Date Tagged	Station	Date Recaptured	Station
13035	1-29-78	Production Platform 296-B	-	-
13036	1-29-78	Production Platform 296-B	-	-
13026	1-29-78	Production Platform 296-B	-	-
13037	1-29-78	Production Platform 296-B	-	-
13063	2-1-78	Production Platform 296-B	5-29-78	Production Platform 296-B
13064	2-1-78	Production Platform 296-B	-	-
13065	2-1-78	Production Platform 296-B	-	-
13066	2-1-78	Production Platform 296-B	6-9-78	Production Platform 296-B
13067	2-1-78	Production Platform 296-B	3-15-78	Production Platform 296-B
13069	2-1-78	Production Platform 296-B	-	-
13070	2-1-78	Production Platform 296-B	6-30-78	Production Platform 296-B
13071	2-1-78	Production Platform 296-B	-	-
13072	2-1-78	Production Platform	-	-
13073	2-1-78	Production Platform 296-B	-	-
13074	2-1-78	Production Platform 296-B	2-20-78	Production Platform 296-B
13075	2-1-78	Production Platform 296-B	-	-
13076	2-1-78	Production Platform 296-B	-	-
13077	2-1-78	Production Platform 296-B	-	-

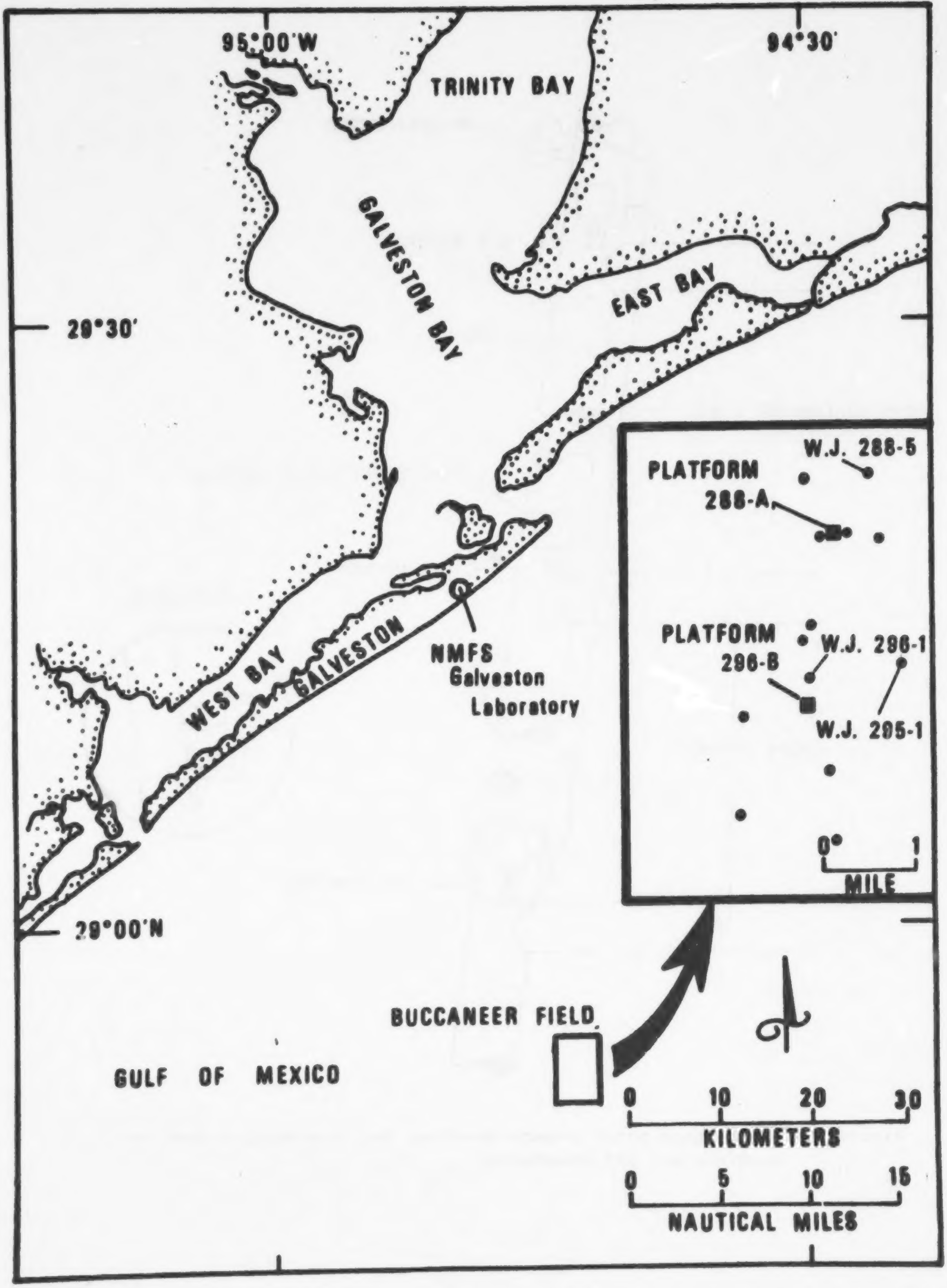

95°00'W
94°30'
TRINITY BAY
GALVESTON BAY
EAST BAY
29°30'
PLATFORM
288-A
W.J. 288-5
PLATFORM
296-B
W.J. 296-1
W.J. 295-1
0
1
MILE
WEST BAY
GALVESTON
NMFS
Galveston
Laboratory
29°00'N
BUCCANEER FIELD
GULF OF MEXICO
0
10
20
30
KILOMETERS
0
5
10
15
NAUTICAL MILES

Figure 1. Map of the Gulf of Mexico offshore from Galveston, Texas, showing the location of production platforms 288-A and 296-B and control well jackets (W.J.) 288-5, 295-1 and 296-1 in the Buccaneer Oil Field.

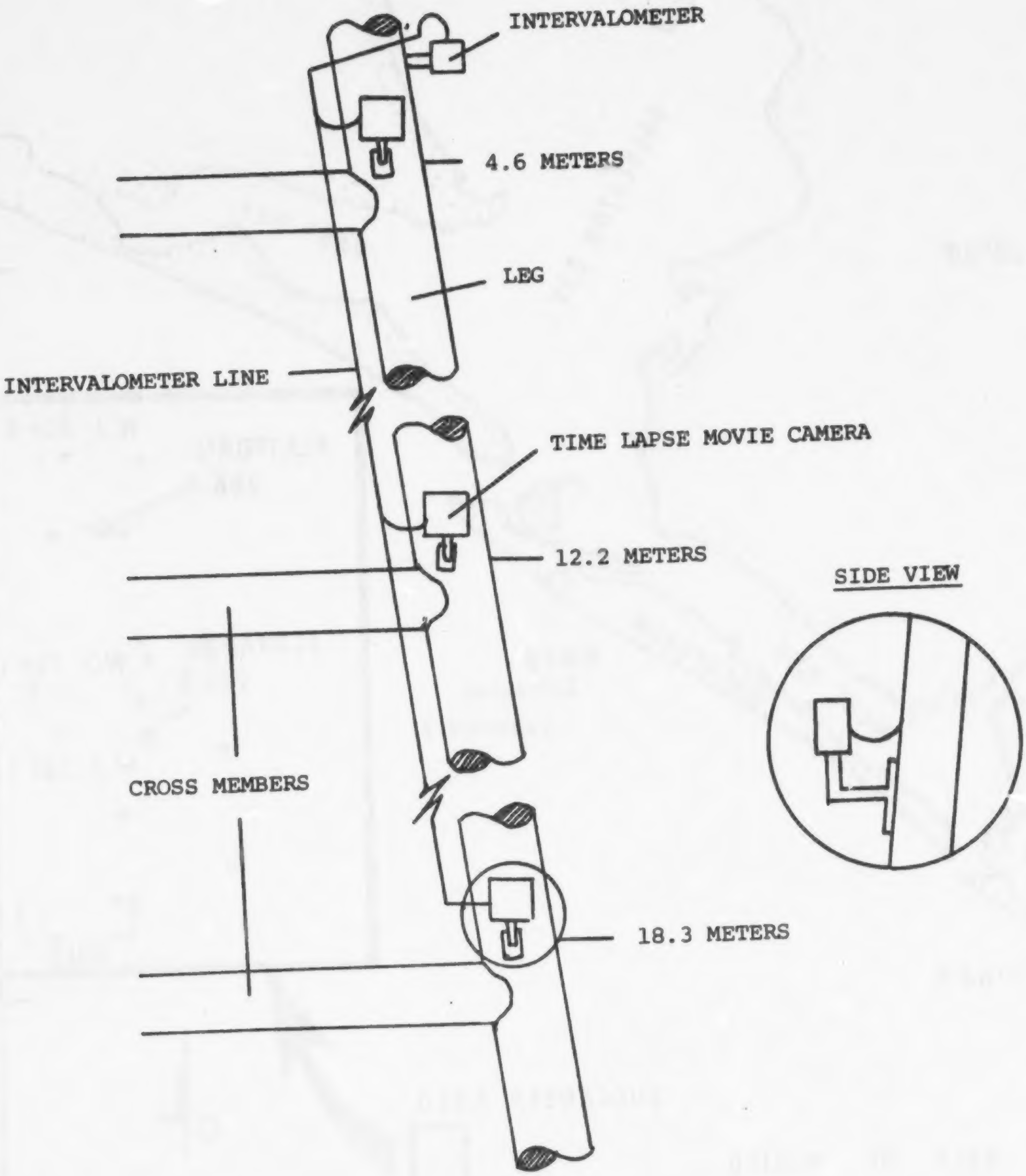

INTERVALOMETER
4.6 METERS
LEG
INTERVALOMETER LINE
TIME LAPSE MOVIE CAMERA
12.2 METERS
SIDE VIEW
CROSS MEMBERS
18.3 METERS

Figure 2. Time-lapse movie camera mounting for determining species composition and abundance.

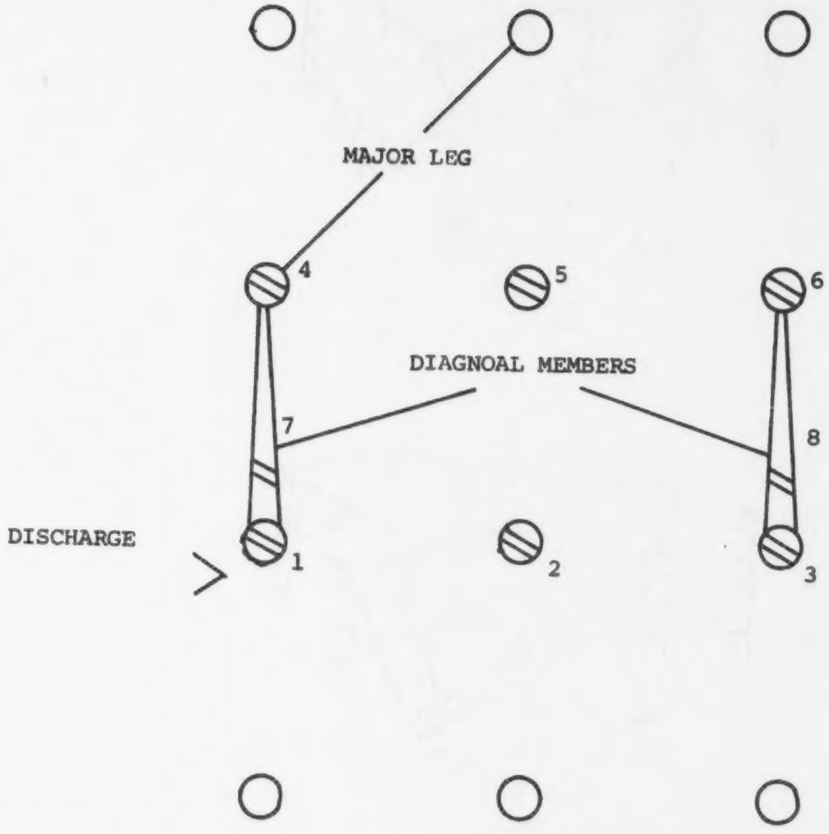

MAJOR LEG
4
5
6
DIAGNOAL MEMBERS
7
8
DISCHARGE
1
2
3

Figure 3. Production platform visual census station legs and diagonals (stations are diagonally cross-hatched).

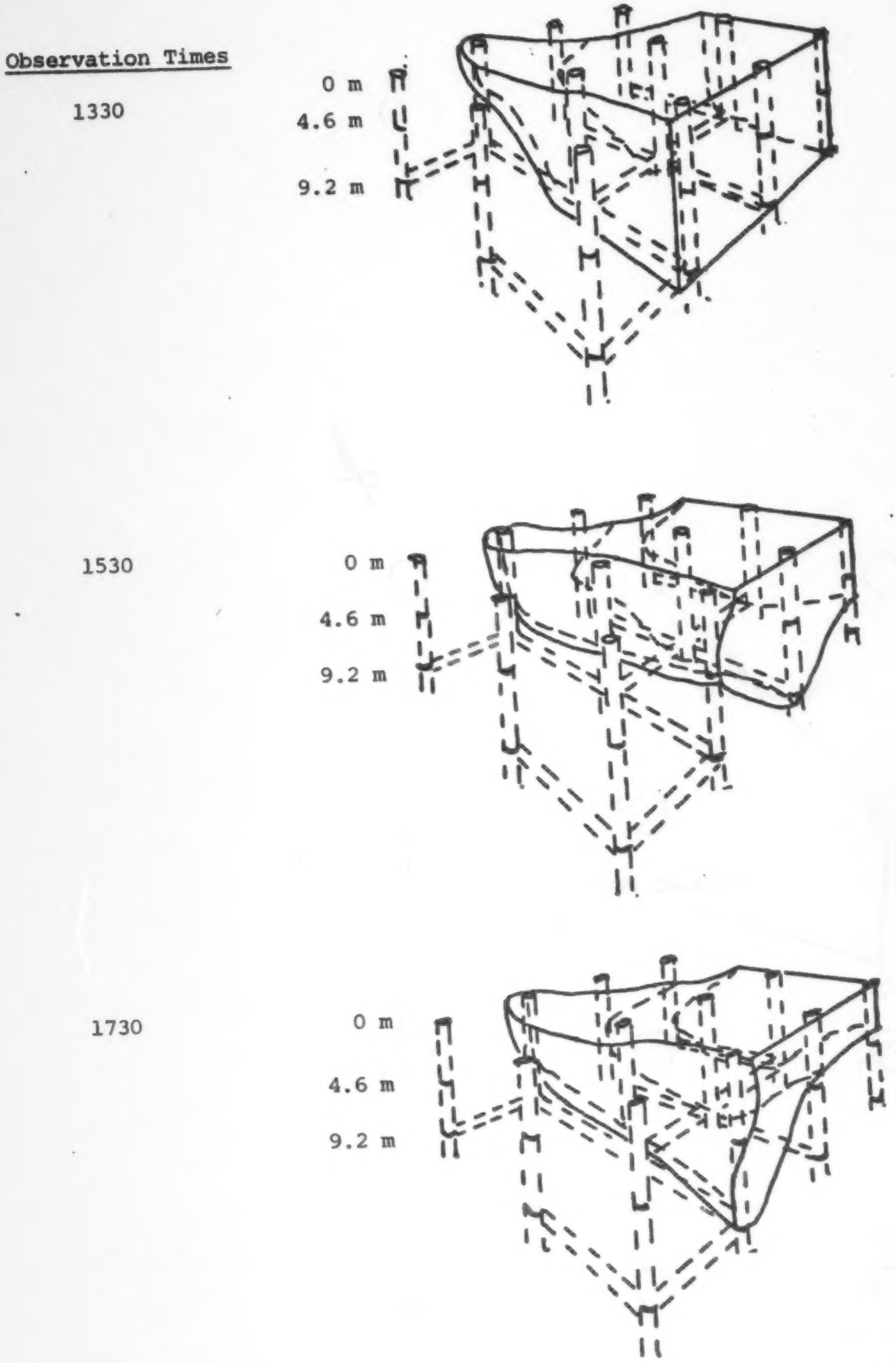

Observation Times
1330
0 m
4.6 m
9.2 m
1530
0 m
4.6 m
9.2 m
1730
0 m
4.6 m
9.2 m

Figure 4. Patterns of dyed effluent discharge under production platform 288-A (August 17, 1977).

Observation Times

1147

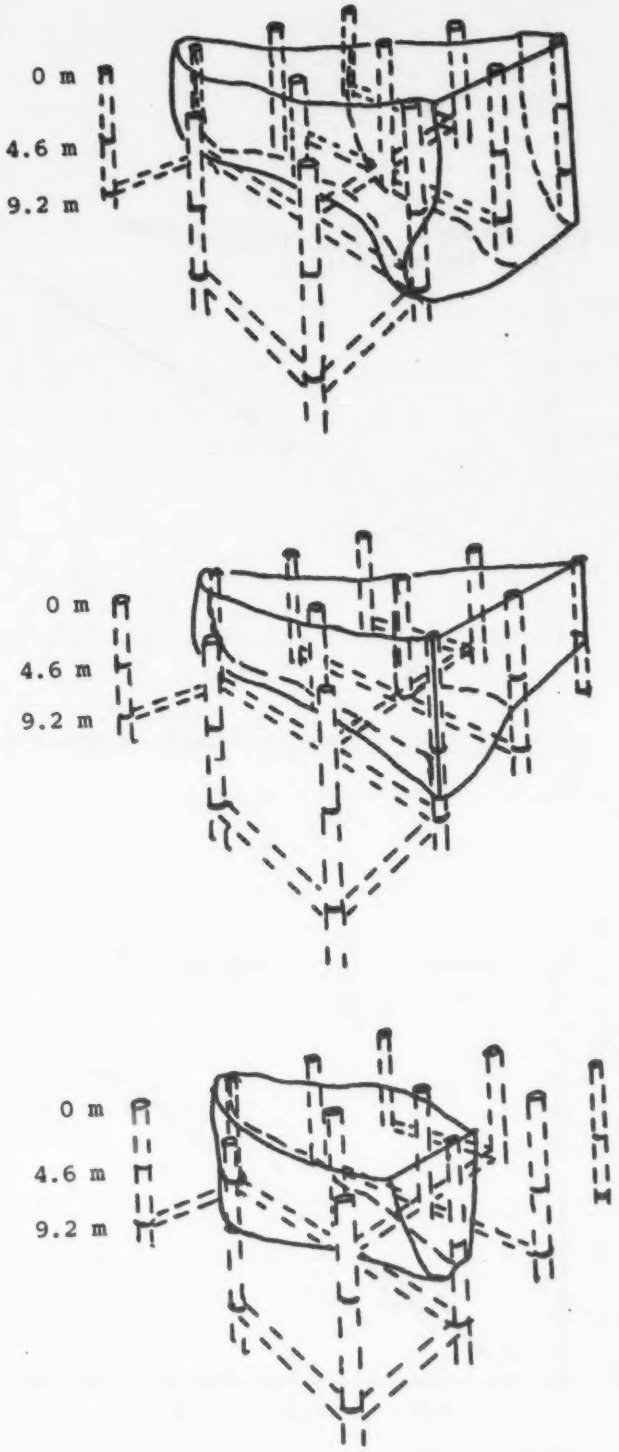
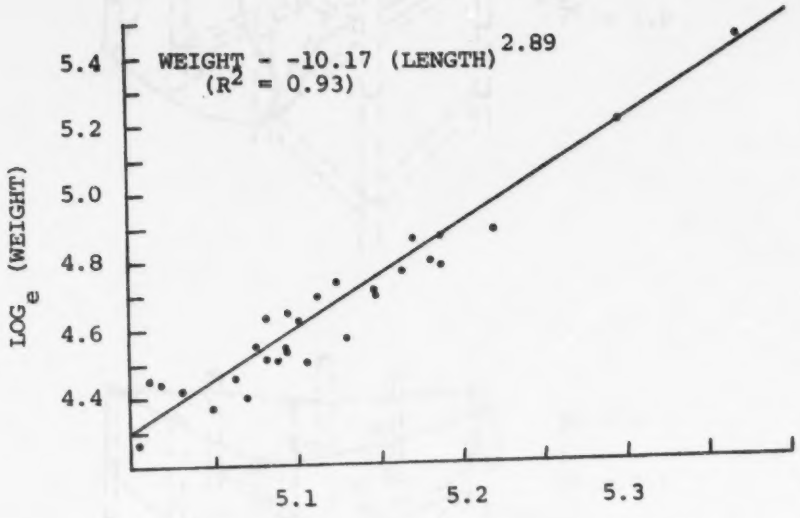
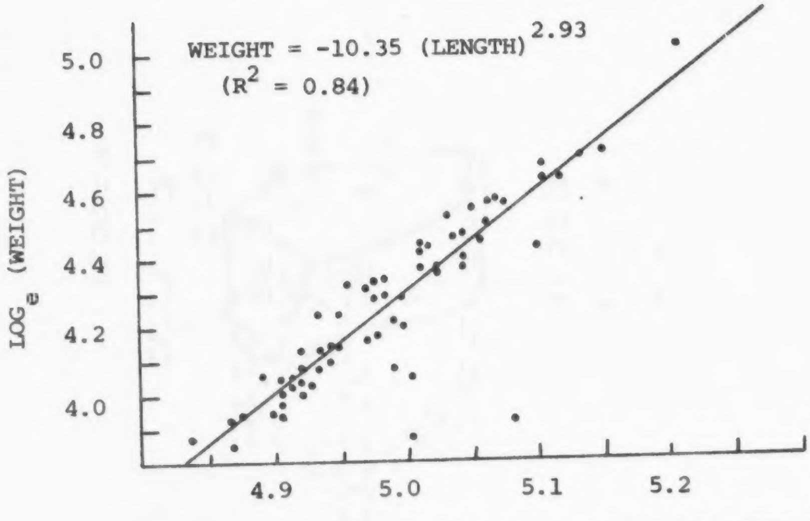

0 m
4.6 m
9.2 m
0 m
4.6 m
9.2 m
0 m
4.6 m
9.2 m

Figure 5. Patterns of dyed effluent discharge under production platform 296-B (November 11, 1977).



Haemulon aurolineatum (Platform 288-A Discharge)



Haemulon aurolineatum (Control Well Jacket 288-5)

Figure 6. Length (mm)-weight (g) relationship differences for *Haemulon aurolineatum* collected at production platform 288-A and the control well jacket 288-5 during summer 1977.

PART B

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Environmental Assessment of an Active Oil Field in the Northwestern Gulf of Mexico

Work Unit 2.3.5 Pelagic and Demersal Finfishes and Macro-Crustaceans: Stomach and Trawl Sample Analysis

Methods and Materials

Trawl Sample Analysis

Trawl collections taken from the Buccaneer Oil Field during October 1977 and March 1978 were removed from freezers at the Galveston Laboratory of the National Marine Fisheries Service (NMFS) and allowed to thaw to room temperatures. To prevent bacteria-caused decay and enzymatic breakdown of tissue (especially food items), care was taken to thaw only those samples which could be processed in an uninterrupted (but reasonable) interval of time. Collections were rough sorted to finfish, macrocrustacea and molluscs.

Finfish were identified to species using keys by Gallaway et al. (1972), Walls (1975), and Hoese and Moore (1977). All fish were measured and weighed individually. For purposes of comparability with previous Buccaneer fisheries data, each fish was measured to the nearest millimeter of fork length [that straightline distance from the most anteriorly projecting part of the head to the tip of the median rays of the caudal fin (Lagler 1968)] and total length [that straightline distance from the most anteriorly projecting part of the head to the farthest tip of the caudal fin when the caudal rays are squeezed together (Hubbs and Lagler, 1967)]. Individual specimens were wet-weighed to the nearest 0.1 g using a Mettler P-1200 top-loading precision electronic balance. Weighing techniques followed procedures outlined by Lagler (1968). The coelomic cavity of each specimen was cut open immediately after the specimen was weighed to expose the digestive tract and gonads. The digestive tract (stomach and intestines) was removed, labelled with a number identifying each specimen, and injected with buffered 10% formalin. Each labelled stomach was wrapped in cheesecloth, placed with other stomachs from the same species in a container of 10% formalin and held for later analysis.

Fish sex was determined by gross inspection of gonads. Where sex was not readily apparent in immature fish, gonads were removed and inspected by microscopy.

Macro-crustaceans were identified to species using keys by Williams (1965), Felder (1973) and Wood (1974). Each macro-crustacean was measured and weighed individually. Shrimp were measured to the nearest millimeter of total length (that straightline distance between the anteriormost tip of the rostrum to the tip of the telson). Crabs were measured to the nearest millimeter of carapace width (that straightline distance between lateral spine tips). Shrimp and crabs were wet-weighed to the nearest 0.1 g on the Mettler P-1200 balance. The sex of all macro-crustaceans was determined by gross visual inspection.

Molluscs were identified to species using keys by Andrews (1977). For purposes of comparability with previous Buccaneer fisheries data, total weight (tissue plus shell) was determined to the nearest 0.1 g.

A voucher collection consisting of properly labelled and preserved specimens of each species or taxon encountered in trawl samples was prepared and archived in the Department of Marine Biology at Moody College, Texas A&M University, Galveston, Texas. A list of voucher specimens is given in Table 1. All other specimens from trawl collections were discarded.

Stomach Sample Analysis

Stomachs from an assortment of species including spanish sardine (Sardinella anchovia), sea catfish (Arius felis), Gulf toadfish (Opsanus beta), whitespotted soapfish (Rypticus maculatus), round scad (Decapterus punctatus), red snapper (Lutjanus campechanus), lane snapper (Lutjanus synagris), tomtate (Haemulon aurolineatum), pigfish (Orthopristis chrysoptera), sheepshead (Archosargus probatocephalus), pinfish (Lagodon rhomboides), cubbyu (Equetus umbrosus), Atlantic croaker (Micropogon undulatus), yellow chub (Kyphosus incisor), Bermuda chub (Kyphosus sectatrix), Atlantic spadefish (Chaetodipterus faber), seaweed blenny (Blennius marmoreus), crested blenny (Hypleurochilus geminatus), shoal flounder (Syacium gunteri) and gray triggerfish (Balistes capriscus) collected during trawling, spearfishing, hook-and-lining, trapping and SCUBA operations in 1977-78 were analyzed for food items. The number of individuals analyzed for each species is given in Table 2.

Stomach analysis entailed the following procedures. Each stomach was cut open and examined under a dissecting microscope to ascertain presence of food items. Food items were washed from the stomach into a sorting dish. After this initial transfer, the stomach again was examined microscopically to ensure that all food items had been removed. Individual food items were sorted, identified to the lowest possible taxon and, when possible, enumerated. Food items which could not be enumerated (i.e., unidentifiable digested matter, fish vertebrae, shell fragments, etc.) were listed as "present."

Gonads from the aforementioned crested blennies also were examined and sexed according to procedures previously described for trawl collections.

Where applicable, all raw data were coded and entered on data forms previously developed and used by NMFS personnel during the Buccaneer study.

Literature Cited

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APPENDIX

Table 1. Macro-invertebrates and Finfish Species Trawled from the Buccaneer Oil Field During October 1977 and March 1978

Invertebrates

Calliactis tricolor
Architectonica nobilis
Busycon contrarium
Busycon perversum
Cantharus cancellarius
Distorsio clathiata
Fasciolaria lillium
Murex fulvescens
Pleuroploca gigantea
Arca sp.
Anadara transversa
Noetia ponderosa
Loliguncula brevis
Chloeia viridis
Squilla empusa
Penaeus aztecus
Sicyonia brevirostra
Sicyonia dorsalis
Sicyonia stimpsoni
Sicyonia typica
Trachypenaeus similis
Pagurus impressus
Petrochirus diogenes
Porcellana sayana
Calappa sulcata
Callinectes sapidus
Callinectes similis
Glyptoxanthus erosus
Hepatus epheliticus
Hexapanopeus paulensis
Libinia dubia
Menippe mercenaria
Parthinope serrata
Petrolisthes armatus
Podochela sydneyi
Portunus spinimanus
Cupuladria canariensis
Astropecten sp.
Ophiolepis paucispina

Fish

Raja texana
Ophichthus gomesi
Synodus foetens
Arius felis
Porichthys porosissimus
Halieutichthys aculeatus
Ogocephalus parvus
Urophycis floridanus
Lepophidium graellsi
Centropristis philadelphica
Diplectrum bivittatum
Lutjanus campechanus
Lutjanus synagris
Eucinostomus argenteus
Haemulon aurolineatum
Orthopristis chrysoptera
Lagodon rhomboides
Stenotomus caprinus
Cynoscion arenarius
Cynoscion nothus
Equetus umbrosus
Micropogon undulatus
Pogonias cromis
Chaetodipterus faber
Polydactylus octonemus
Peprilus alepidotus
Scorpaena calcarata
Prionotus ophryas
Prionotus roseus
Prionotus rubio
Ancylopsetta quadrocellata
Citharichthys spilopterus
Cyclopsetta chittendeni
Etropus crossotus
Syacium gunteri
Gymnachirus texae
Symphurus plagiusa
Sphoeroides parvus

Table 2. Fish species and number of individuals analyzed for stomach contents, Buccaneer Oil Field Study 1977-78

Species	Number
Sardinella anchovia (spanish sardine)	2
Arius felis (sea catfish)	330
Opsanus beta (Gulf toadfish)	1
Rypticus maculatus (whitespotted soapfish)	4
Decapterus punctatus (round scad)	3
Lutjanus campechanus (red snapper)	57
Lutjanus synagris (lane snapper)	4
Haemulon aurolineatum (tomtate)	84
Orthopristis chrysoptera (pigfish)	4
Archosargus probatocephalus (sheepshead)	2
Lagodon rhomboides (pinfish)	1
Equetus umbrosus (cubbyu)	15
Micropogon undulatus (Atlantic croaker)	25
Kyphosus incisor (yellow chub)	1
Kyphosus sectatrix (Bermuda chub)	1
Chaetodipterus faber (Atlantic spadefish)	15
Blennius marmoreus (seaweed blenny)	6
Hypleurochilus geminatus (crested blenny)	173
Syacium gunteri (shoal flounder)	172
Balistes capriscus (gray triggerfish)	2

Taxonomic List Of Food Items Taken From Buccaneer Oil Field Fish Stomachs

Code	Taxon
00000	Algae
00100	Class Rhodophyta
00110	Order Nemaliales
00111	*Adouinella* sp.
00120	Order Ceramiales
00121	*Antithamnion* sp.
00200	Class Chlorophyta
00210	Order Cladophorales
00211	*Cladophora* sp.
01000	Phylum Cnidaria
01100	Class Hydrozoa
01101	Unidentifiable Hydroid Fragment
01200	Class Anthozoa
01201	Unidentifiable Actinaria (sea anemone)
03000	Phylum Platyhelminthes
03100	Class Cestoda
03101	Unidentifiable Tapeworm
04000	Phylum Nematoda
04001	Unidentifiable Nematode
05000	Phylum Acanthocephala
05001	Unidentifiable Acanthocephalan
06000	Phylum Bryozoa
06100	Class Gymnolaemata
06101	*Bugula neritina*

07000	Phylum Mollusca
07100	Class Gastropoda
07101	*Creseis acicula*
07102	*Cantharus cancellarius*
07103	Unidentifiable Gastropod Remains
07200	Class Bivalvia
07201	*Nuculana concentrica*
07202	Unidentifiable Bivalve Remains
07300	Class Cephalopoda
07301	*Octopus* sp.
08000	Phylum Annelida
08100	Class Polychaeta
08101	*Sthenelais boa*
08102	*Lepidasthenia* sp.
08103	Family Phyllodocidae
08104	*Glycera americana*
08105	*Nephthys* sp.
08106	*Lumbrineris tenuis*
08107	*Diopatra cuprea*
08108	*Paraprionospio pinnata*
08109	*Armandia maculata*
08110	Family Maldanidae
08111	Family Terebellidae
08112	*Terebellide stroemi*
08113	Ampharetidae
08114	*Ampharete acutifrons*
08115	Unidentifiable Polychaete Remains

09000	Phylum Arthropoda
09100	Class Crustacea
09101	Subclass Ostracoda
09102	Unidentifiable Ostracod
09103	Subclass Cirripedia
09104	Barnacle Remains
09105	Subclass Copepoda
09106	Order Harpacticoida
09107	Unidentifiable Harpacticoid Copepod
09108	Subclass Malacostraca
09109	Order Stomatopoda
09110	*Squilla empusa*
09111	Stomatopod zoea
09112	Superorder Peracarida
09113	Order Amphipoda
09114	*Ampelisca abdita*
09115	*Ampelisca agassizi*
09116	*Ampelisca verrilli*
09117	*Ampelisca* sp.
09118	*Caprella equilibra*
09119	*Corophium acherusicum*
09120	*Elasmopus rapax*
09121	*Grandidierella bonnieroides*
09122	*Jassa falcata*
09123	*Monoculodes edwardsi*
09124	*Photis texensis*
09125	*Photis* sp.
09126	*Podocerus brasiliensis*

09127	*Sthenothoe* sp.
09128	Unidentifiable Amphipod Fragment
09129	*Elasmopus levis*
09140	Order Mysidacea
09141	*Mysidopis bigelowi*
09150	Order Cumacea
09151	*Oxyurostylis salinoi*
09160	Order Tanaidacea
09161	*Tanais cavolini*
09170	Superorder Eucarida
09171	Order Decapoda
09172	*Trachypeneus similis*
09173	*Sicyonia* sp.
09174	Unidentifiable Penaeid Shrimp (adult)
09175	Unidentifiable Penaeid Shrimp (postlarva)
09176	Unidentifiable Penaeid Shrimp (zoea)
09177	*Automate evermanni*
09178	*Leander* sp.
09179	*Leptochela serratorbita*
09180	*Alpheus floridanus*
09181	*Alpheus* sp.
09182	Unidentifiable Caridean Shrimp
09183	*Callianassa* sp.
09184	*Euceramus praelongus*
09185	*Petrochirus diogenes*
09186	Unidentifiable Brachyuran Remains
09187	*Persephona crinata*

09188	*Persephona* sp.
09189	*Hepatus pudibundis*
09190	*Hepatus* sp.
09191	*Calappa* sp.
09192	Unidentifiable Portunid Crab Remains
09193	*Menippe mercenaria*
09194	Unidentifiable Xanthid Crab Remains
09195	*Spiocarcinus lobatus*
09196	*Pinnixa sayana*
09197	Unidentifiable Decapod Remains
09198	Unidentifiable Crustacean Remains
09199	Unidentifiable Crab Zoea
09200	Class Insecta
09201	Order Coleoptera
09202	Beetle elytra
10000	Phylum Echinodermata
10100	Class Ophiuroidea
10101	*Hemipholis elongata*
10102	*Micropholis atea*
10103	Unidentifiable Ophiuroid Fragments
10200	Class Holothuroidea
11000	Phylum Chordata
11100	Class Osteichthys
11101	Unidentifiable Fish Remains
12000	Miscellaneous Food Items
12001	Plastic Spheres
12002	Pebbles

12003	Unidentifiable Animal Matter
12004	Unidentifiable Plant Matter
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INTRODUCTION

Data analyzed consisted of those collected for the 1976-77 Work Unit 2.3.4 "Demersal fishes and macro-crustaceans" and 2.3.5 "Recreational fisheries and the distribution of predatory pelagic fishes" and 1977-78 Work Unit 2.3.5 "Pelagic and demersal fishes and macro-crustaceans". The data analyses consisted of data reduction and synthesis techniques as well as statistical procedures. These analyses were intended for use by NMFS personnel as a basis for the publication of results of the investigations.

Data from the 1976-77 studies included length, weight, and number of individuals per sample from trawl, trap, hook-and-line, gill net, and long-line collections. The bulk of these data were collected by trawl. The 1977-78 studies consist of similar data collected by trawl, trap, hook-and-line, and divers. Visual diver observation and photographic techniques were also used to document presence, location, and density (per unit volume) of fishes.

The raw data were forwarded to LGL from the National Fisheries Engineering Laboratory (NFEL) in NSTL Station, MS. The data from the trawl collections were subjected to cluster analysis techniques. Length-weight data from blennies collected from the BOF were compared using analysis of covariance techniques. Trap net, hook-and-line, long-line, and gill net data were summarized tabularly, including numerical abundance and biomass observations. Diver observation and camera census information was summarized and estimates of number per square meter and number per cubic meter, respectively, were calculated and presented.

Stomach contents data from the 1977-78 BOF study were received from NFEL on 6 September 1978. We had originally intended to compute Index of Fullness values for the fish analyzed. However, since individual weights of stomach contents were not provided, this analysis was precluded. Instead, the data were summarized on a fish species by station by season basis (Tables 14-60). In addition, the percent of stomachs examined which contained a particular food item was calculated. Since the vast majority of the data consisted of presence-absence data, more complicated analyses were precluded.

METHODS

Data summarization, synthesis, and statistical analysis were primarily performed at Texas A&M University's Data Processing Center using the data management and statistical capabilities of the Statistical Analysis System (SAS). Since the data received from NFEL had been subjected to verification, we did not repeat this process. We did, however, scan the data for obvious outliers prior to analysis. Suspicious data were verified with NMFS personnel at Galveston. Computer outputs were transferred to IBM typeface and/or line drawings for clarity of reproduction and ease in transfer and understanding.

Cluster analysis techniques were used on trawl data to explore associations between collecting sites and dates and to elucidate species (taxa) associations. Cluster analysis involves the use of a dissimilarity measure to determine the degree of association between pair-wise combinations of data units based on some variables (Clifford and Stephenson 1975). For our application, the data units consisted of collections while the number of specimens of each taxa comprised the variables. The clustering of data units (collections) based on the variables (taxonomic composition) is referred to as a normal analysis. An inverse analysis, clustering variables (taxa) based on data units (collections) was also performed. The Bray-Curtis dissimilarity measure was utilized for analysis using a flexible sorting strategy with the cluster intensity coefficient set at -0.25 following the recommendations of Clifford and Stephenson (1975). To reduce the bias of a few disproportionately high values, a square-root transformation was performed on the catch data for the normal analysis. For the inverse analysis, a norm standardization was applied in addition to the square-root. The results of the cluster analysis were displayed as dendograms, one for the normal and one for the inverse analysis. A two-way table was also produced to show the relationship between sites and taxa clusters. Since no satisfactory statistical methods are presently available, major clusters or groups were separated based upon the degree of dissimilarity exhibited in the dendograms and characteristics of the two-way table. Cluster analysis was performed using the program CLASS developed and installed at the Texas A&M University Data Processing Center by Dr. Robert Smith of the University of Southern California.

Length-weight relationships for blennies were compared using analysis of covariance (AOCV) techniques (after LeCren 1951). The technique as applied here consisted of a General Linear Model Theory lack of fit test (R.J. Fruend, Institute of Statistics, Texas A&M University, personal communication) in which (1) the overall regression relationship was determined and tested, followed by (2) separate, yet parallel, relationships for each treatment, and finally (3) separate regression with unequal slopes. For our application the third test tells us if the relationships are best described as separate regression equations. If this test indicates statistical significance, then standard AOCV techniques are not valid. If the third test is nonsignificant, then the second test tells us if the relationships are adequately described as parallel regression lines. If the second test is significant, then standard AOCV tests can be used. If it is not significant, then AOCV tests are unnecessary, and the first test of the lack of fit analysis becomes important because it tests for a single regression relationship over all treatments.

The length-weight relationship for fish has the general form:

$$W = aL^b$$

where W is weight, L is length, and a and b are constants. In order to perform AOCV it is first necessary to linearize the equation. This is done by taking the logarithm of both sides of the equation. The linear equation then takes the form:

$$\log W = \log a + b \log L.$$

In this form the General Linear Model lack of fit tests can be applied.

RESULTS

Lists of common and scientific names of fishes and macroinvertebrates were compiled by hand from the computerized lists of scientific names and bionumeric codes provided by NFEL (Tables 1 and 2). These lists were included to aid in understanding and interpreting the tables and figures which follow.

Trap Net

Traps were fished both years (Tables 3-5). During 1976-78, bottom and floating traps were fished both in and out of the BOF. The traps were best at collecting structure-oriented fishes and macro-crustaceans. During 1977-78, traps were fished at various locations on specific BOF structures. Only fish species were listed as being captured. Most of these were structure-oriented species.

Gill Net

Three gill net collections were made on two dates during 1976 (Table 6). Only four species of fish were collected, with only one individual per species in any one collection. Weights were not provided for these fishes.

Long-line

Long-lines were fished during the summer 1976 (Table 7). The majority of the fishes collected were sharks; of these the tiger shark, *Galeocerdo cuvieri*, was most numerous. One large bull shark, *Carcarhinus leucos*, (127.7 kg) dominated the recorded weights. Non-sharks included shark-sucker, *Echeneis naucrates*; blue runner, *Caranx crysos*; and King mackerel, *Scomberomorus cavalla*.

Visual diver census

Visual diver census over known surface areas of BOF structures was performed during 1977-78 (Table 8). Estimates of numerical density per square meter of structure surface area at times ranged from less than 1.0/m^2 for belted sandfish, *Serranus subligaris*; whitespotted soapfish, *Rypticus maculatus*; and sheepshead, *Archosargus probatocephalus* to occasionally over 50.0/m^2 for blennies (Fam. Blenniidae). Stone crabs, *Menippe mercenaria*; cocoa damselfish, *Pomacentrus variabilis*; and blennies were generally the most numerously observed species.

Underwater camera census

Pelagic fishes were observed by underwater camera around BOF structures during 1977-78 (Table 9). Average densities ranged from less than 0.001/m^3 on several occasions to almost 0.25/m^3 for pinfish, *Lagodon rhomboides* on one occasion. Sheepshead and Atlantic spadefish were seen most often. A large number of fish were unidentifiable from the pictures. Other species observed included blue runner, *Caranx crysos;*

Atlantic moonfish, *Vomer setapinnis*; tomtate, *Haemulon aurolineatum*; great barracuda, *Sphyraena barracuda*; and gray triggerfish, *Balistes capriscus*.

Trawl

Trawl collections were made both years. During 1976-77, trawl tows were 20 minutes to 90 minutes in duration; during 1977-78 they were 5 minutes in duration. Because of the magnitude of difference in tow duration, the two years were analyzed separately. Prior to analysis of the 1976-77 collections, the data was standardized to a common level of effort. To avoid numbers less than 1.0, 20 minutes was chosen as the standard effort. No standardization of 1977-78 effort was necessary since all tows were 5 minutes in duration. Following standardization, the data were subjected to cluster analysis techniques.

1976-77--The normal (collection) analysis resulted in four distinct clusters (Fig. 1). One cluster (A) was comprised of spring (May 1976) collections. Another (D) was comprised of summer (August 1976) collections. The third (B) was made-up of fall (November 1976) and winter (February 1977) collections. The fourth (C) included two collections in which few organisms were collected and hence failed to be associated with the other collections. Within the fall-winter cluster (B), the November and February collections remained distinct even if not at a level great enough to be given cluster status.

The inverse (taxa) analysis resulted in 6 clusters (Fig. 2). These clusters were not as distinct as those in the normal analysis. The association of taxa with collections is best illustrated in the two-way table (Fig. 3). Taxa in clusters I and II were essentially taken year-round in scattered collections. Those in cluster IV were also collected year-round, but were not regularly caught in summer. Clusters III and V represent relatively rare taxa in the collections. Cluster VI is composed of the more ubiquitus taxa.

1977-78--The normal analysis yielded two distinct clusters (Fig. 4). Cluster A was comprised primarily of fall (1977) collections; one winter (1978) collection was included. The second cluster (B) was composed of winter collections.

The inverse analysis was comprised of three major clusters (Fig. 5). Cluster I represented taxa collected sparingly during fall (Fig. 6). Cluster II taxa were generally relatively numerous during fall and relatively rare during winter. The third cluster (III) was composed of both rare and abundant taxa which were present in both fall and winter collections.

Blennies

Blennies were collected by air lift during 1977-78 (Table 10). Length-weight data on blennies collected during 1977-78 were analyzed, and the results transmitted to NMFS personnel in Galveston for inclusion in earlier reports. The results of these analyses are summarized in Tables 11 and 12. The analyses indicated that all log transformed blenny length-weight relationships could be adequately described as parallel lines.

Thus, AOCV techniques could validly be used. The results of the AOCV tests indicated no significant differences between any of the tested length-weight relationships.

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APPENDIX

Table 1 . Common and scientific names of fishes from the Buccaneer Oil Field Study Area.

Common Name	Scientific Name
Blacknose shark	*Carcharhinus acronotus*
Blacktip shark	*Charcharhinus limbatus*
Atlantic Sharpnose shark	*Rhizoprionodon terraenovae*
Roundel skate	*Raja texana*
Southern stingray	*Dasyatis americana*
Shrimp eel	*Ophichthus gomesi*
Palespotted eel	*Ophichthus ocellatus*
Threadfin shad	*Dorosoma petenense*
Round herring	*Etrumeus teres*
Scaled sardine	*Harengula jaguana*
Atlantic thread herring	*Opisthonema oglinum*
Largescale lizzardfish	*Saurida brasiliensis*
Inshore lizzardfish	*Synodus foetens*
Sea catfish	*Arius felis*
Gulf toadfish	*Opsanus beta*
Leopard todafish	*Opsanus pardus*
Atlantic midshipman	*Porichthys porosissimus*
Pancake batfish	*Halieutichthys aculeatus*
Roughback batfish	*Ogcocephalus parvus*
Southern hake	*Urophycis floridanus*
Blackedge cusk eel	*Lepophidium graellsi*
Crested cusk eel	*Ophidion welshi*
Cusk eel	*Rissola* sp.
Striped cusk eel	*Rissola marginata*
Rough silverside	*Membras martinica*
Rock sea bass	*Centropristis philadelphica*
Dwarf sand perch	*Diplectrum bivittatum*
Sand perch	*Diplectrum formosum*
Pygmy sea bass	*Serraniculus pumilio*
Belted sandfish	*Serranus subligaris*
Whitespotted soapfish	*Rypticus maculatus*
Greater soapfish	*Rypticus saponaceus*
Remora	*Remora remora*
Blue runner	*Caranx crysos*
Horse-eye jack	*Caranx latus*
Atlantic bumper	*Chloroscombrus chrysurus*
Rough scad	*Trachurus lathami*
Atlantic moonfish	*Vomer setapinnis*
Red snapper	*Lutjanus campechanus*
Lane snapper	*Lutjanus synagris*
Spotfin mojarra	*Eucinostomus argenteus*
Silver jenny	*Eucinostomus gula*
Mottled mojarra	*Eucinostomus lefroyi*
Tomtate	*Haemulon aurolineatum*

Table 1 . (cont'd)

Common Name	Scientific Name
Cottonwick	*Haemulon macrostomum*
Striped grunt	*Haemulon striatum*
Pigfish	*Orthopristis chrysoptera*
Pinfish	*Lagodon rhomboides*
Longspine porgy	*Stenotomus caprinus*
Sand seatrout	*Cynoscion arenarius*
Silver seatrout	*Cynoscion nothus*
High hat	*Equetus acuminatus*
Cubbyu	*Equetus umbrosus*
Banded drum	*Larimus fasciatus*
Spot	*Leiostomus xanthurus*
Southern kingfish	*Menticirrhus americanus*
Atlantic croaker	*Micropogon undulatus*
Black drum	*Pogonias cromis*
Red drum	*Sciaenops ocellata*
Dwarf goatfish	*Upeneus parvus*
Atlantic spadefish	*Chaetodipterus faber*
Spotfin butterflyfish	*Chaetodon ocellatus*
Atlantic threadfin	*Polydactylus octonemus*
Seaweed blenny	*Blennius marmoreus*
Crested blenny	*Hypleurochilus geminatus*
Atlantic cutlassfish	*Trichiunis lepturus*
Butterfish	*Peprilus* sp.
Gulf butterfish	*Peprilus burti*
Smoothhead scorpionfish	*Scorpaena calcarata*
Horned searobin	*Bellator militaris*
Bandtail searobin	*Prionothus ophryas*
Blackfin searobin	*Prionotus rubio*
Blackwing searobin	*Prionotus salmonicolor*
Ocellated flounder	*Ancylopsetta quadrocellata*
Bay whiff	*Citharichthys spilopterus*
Mexican flounder	*Cyclopsetta chittendeni*
Fringed flounder	*Etropus crossotus*
Smallmouth flounder	*Etropus microstomus*
Gulf flounder	*Paralichthys albigutta*
Windowpane	*Syacium gunteri*
Dusky windowpane	*Syacium papillosum*
Fringed sole	*Gymnachirus texae*
Offshore tonguefish	*Symphurus civitatus*
Spottedfin tonguefish	*Symphurus diomedianus*
Blackcheek tonguefish	*Synphurus plagiusa*
Gray triggerfish	*Balistes capriscus*
Planehead filefish	*Monacanthes hispidus*
Scrawled cowfish	*Lactophrys quadricornis*
Smooth puffer	*Lagocephalus laevigatus*
Least puffer	*Sphoeroides parvus*
Bandtail puffer	*Sphoeroides splengeri*
Striped burrfish	*Chilomycterus schoepfi*

Table 2. Common and scientific names of macroinvertebrates from from the Buccaneer Oil Field Study Area.

Common Names	Scientific Names
Mantis shrimp	*Squilla empusa*
Mantis shrimp	*Squilla neglecta*
Brown shrimp	*Penaeus aztecus*
Pink shrimp	*Penaeus duorarum*
White shrimp	*Penaeus setiferus*
Rock shrimp	*Sicyonia brevirostris*
Chevron shrimp	*Sicyonia dorsalis*
Shrimp	*Sicyonia stimponi*
Shrimp	*Sicyonia typica*
Brokenback shrimp	*Solenocera vioscai*
Sugar shrimp	*Trachypenaeus similis*
Mud crab	*Glyptoxanthus erosus*
Stone crab	*Menippe mercenaria*
Speckled crab	*Arenaeus cribrarius*
Gulf crab	*Callinectes danae*
Blue crab (small)	*Callinectes ornatus*
Blue crab	*Callinectes sapidus*
Pigmy blue crab	*Callinectes similis*
Swimming crab	*Portunus anceps*
Swimming crab	*Portunus gibbesii*
Swimming crab	*Portunus spinimanus*
Lady crab	*Ovalipes ocellatus guadulpensis*
Crab	*Calappa angusta*
Box crab	*Calappa sulcata*
Calico crab	*Hepatus epheliticus*
Porcelain crab	*Porcellana sayana*
Hermit crab	*Pagurus impressus*
Red hermit crab	*Petrochirus habamensis*
Spider crab	*Libinia* sp.
Spider crab	*Libinia emarginata*
Spider crab	*Parthenope pourtalesii*
Purse crab	*Myropsis quinquespinosa*

Table 2. (cont'd)

Common Names	Scientific Names
Arrow crab	*Metoporhaphis calcarata*
Purse crab	*Persephona punctata aquilonaris*
Purse crab	*Persephona crinata*
Crab	*Petrilisthes armatus*
Crab	*Podochela sidnaeji*
Common sundial	*Architectonica nobilis*
Atlantic distorsio	*Distorsio clathrata*
Giant Eastern murex	*Murex fulvescens*
Cancellate cantharus	*Cantharus cancellarius*
Whelk	*Busycon contrarum*
Lightning Whelk	*Busycon perversum*
Banded tulip shell	*Fasciolaria lillium*
Florida horse conch	*Pleuroploca gigantea*
Transverse Ark	*Anadara transversa*
Ponderous Ark	*Noetia ponderosa*
Scallop	*Astropecten* sp.
Atlantic squid	*Loligo pealei*
Short squid	*Loliguncula brevis*
Brittle star	*Ophiolepis*
Sea anemone	*Calliactis tricolor*
Anemone	*Chloeia viridis*
Unidentified anemone	

Table 3. Total weight (g) and number of each species collected by bottom trap for each date and station during the 1976-77 Buccaneer Oil Field Study.

Date	Station*	Species	Weight (g)	Number
5/16/76	1P	*Caranx crysos*	1,475.0	1
		Haemulon macrostomum	30.4	1
		Callinectes sapidus	189.8	1
		Portunus spinimanus	5.1	1
		Unknown crustacean	2.4	3
		Hepatus epheliticus	145.4	4
5/17/76	1Y	*Lutjanus campechanus*	19.3	1
		Libinia emarginata	560.4	2
		Callinectes danae	6.8	1
		Portunus gibbesii	4.4	1
		P. spinimanus	11.4	2
		Unknown crustacean	6.6	1
		Porcellana sayana	0.1	1
5/18/76	1X	*Arius felis*	311.1	1
		Callinectes sapidus	674.5	4
		Portunus gibbesii	5.8	1
		P. spinimanus	1.5	1
8/09/76	1X	*Arius felis*	380.5	3
		Lutjanus campechanus	1,562.7	5
		Callinectes danae	850.0	1
		C. sapidus	2,284.0	1
8/10/76	1P	*Rypticus maculatus*	373.8	4
		Lutjanus campechanus	365.8	2
		Haemulon aurolineatum	227.9	3
		Equetus umbrosus	991.5	8
8/11/76	1Y	*Lutjanus campechanus*	1,586.2	10
		Libinia emarginata	1,104.4	4
		Callinectes danae	383.1	9
		C. sapidus	886.0	5
		Porcellana sayana	-	51
11/15/76	1P	*Arius felis*	1,605.0	9
		Lutjanus campechanus	8,653.0	6
		Equetus umbrosus	204.7	2
11/17/76	1Y	*Lutjanus campechanus*	30.8	1
		Orthopristis chrysopterus	199.9	5
		Libinia emarginata	472.0	2
11/18/76	1X	*Arius felis*	17.5	2
		Micropogon undulatus	125.2	2
		Lagodon rhomboides	32.5	1
		Callinectes danae	18.1	1
2/16/77	1P	*Orthopristis chrysopterus*	2,058.3	10
		Chaetodipterus faber	227.3	1
		Opsanus pardus	710.5	1
		Callinectes sapidus	9.5	2

*See Table 14 for Station locations.

Table 4. Total weight (g) and number of each species collected by floating trap for each date and station during the 1976-77 Buccaneer Oil Field Study.

Date	Station*	Species	Weight (g)	Number
11/15/76	2P	*Arius felis*	142.9	1
		Lutjanus campechanus	1,982.0	8
		Equetus umbrosus	273.9	3
11/17/76	2Y	*Orthopristis chrysopterus*	61.5	1
		Libinia emarginata	207.8	1
11/18/76	2X	*Arius felis*	65.1	1
		Orthopristis chrysopterus	27.3	1
		Micropogon undulatus	53.0	1
		Libinia emarginata	186.8	1
		Callinectes danae	22.3	1
		Portunus spinimanus	48.3	1
2/15/77	2X	*Ophichthus ocellatus*	815.2	2
		Libinia emarginata	180.4	1
2/16/77	2P	*Orthopristis chrysopterus*	697.8	5

*See Table 14 for Station locations.

Table 5 . Weight (g) and number of fishes collected by trap net during the 1977-1978 Buccaneer Oil Field Study.

Date	Station *	Species	weight (g)	number
8/16/77	A1	no fish collected	0.0	0
8/16/77	A2	no fish collected	0.0	0
8/16/77	A3	*Serranus subligaris*	2.3	1
		Lutjanus campechanus	579.1	4
		Haemulon aurolineatum	2186.3	21
		Orthopristis chrysopterus	411.3	2
		Equetus umbrosus	389.4	4
		Pogonias cromis	1000.0	1
		Lagodon rhomboides	37.8	1
8/16/77	C1	*Chaetodipterus faber*	1200.0	1
8/16/77	C2	*Rypticus maculatus*	68.1	1
		Haemulon aurolineatum	2961.4	24
8/16/77	C3	*Lutjanus campechanus*	2097.7	15
		Haemulon aurolineatum	3522.0	51
		Equetus umbrosus	1069.8	10
		Balistes capriscus	149.1	1
10/25/77	A1	no fish collected	0.0	0
10/25/77	A2	no fish collected	0.0	0
10/25/77	A3	*Rypticus maculatus*	334.1	3
		Haemulon aurolineatum	80.7	1
		Chaetodon ocellatus	7.6	1
		Opsanus beta	733.3	1
10/25/77	C1	no fish collected	0.0	0
10/25/77	C2	no fish collected	0.0	0
10/25/77	C3	*Lutjanus campechanus*	207.5	1
		Haemulon aurolineatum	162.2	2
10/26/77	NA3	*Arius felis*	6453.6	27
		Lutjanus campechanus	1750.0	1
		Orthopristis chrysopterus	230.0	2
10/27/77	DA3	*Lutjanus campechanus*	413.4	1
		Orthopristis chrysopterus	36.6	1
		Equetus umbrosus	117.6	1

Table 5 . (cont'd)

Date	Station*	Species	weight (g)	number
2/23/78	B2	no fish collected	0.0	0
2/23/78	B3	*Lutjanus campechanus*	2010.0	1
		Equetus umbrosus	138.4	1
2/23/78	C2	no fish collected	0.0	0
2/23/78	C3	*Lutjanus campechanus*	133.2	1
		Equetus umbrosus	663.8	12

*See Table 14 for Station locations.

Table 6. Total weight (g) and number of each species collected by gill net for each date and station during the 1976-77 Buccaneer Oil Field Study.

Date	Station*	Species	Weight	Number
8/04/76	20	*Echeneis naucrates*	-	1
8/06/76	F	*E. naucrates*	-	1
	27	*Dorosoma petenense*	-	1
		Echeneis naucrates	-	1
		Chloroscombrus chrysurus	-	1
		Cynoscion arenarius	-	1

*See Table 14 for Station locations.

Table 7. Total weight (g) and number of each species collected by longline for each date and station during the 1976-77 Buccaneer Oil Field Study.

Date	Station*	Species	Weight	Number
8/04/76	26	*Carcharhinus leucas*	-	1
		Galeocerdo cuvieri	-	1
		Echeneis naucrates	0	1
		Caranx crysos	0	1
8/31/76	22	*Carcharhinus acronotus*	18,200	3
		C. leucas	127,700	1
		Rhizoprionodon terraenovae	2,400	1
		Galeocerdo cuvieri	2,100	1
	27	*Carcarhinus acronotus*	18,400	3
9/23/76	26	*C. acronotus*	-	1
		Galeocerdo cuvieri	-	1
	52	*G. cuvieri*	-	12
	7	*G. cuvieri*	-	2
9/24/76	25	*Carcarhinus acronotus*	7,600	1
		Rhizoprionodon terraenovae	3,300	1
		Galeocerdo cuvieri	3,400	2
		Scomberomorus cavalla	4,500	1
	51	*Rhizoprionodon terraenovae*	12,300	4
		Scomberomorus cavalla	-	1
	6	*Carcarhinus leucas*	-	1
		Galeocerdo cuvieri	4,000	1
		Echeneis naucrates	800	1

*See Table 14 for Station locations.

Table 8. Average number/m^2 of fish and macroinvertebrates observed during diver transects in the 1977-78 Buccaneer Oil Field Study.

Taxa	Season	Station*	Number/m^2
Blue Crab	Summer	03	1.00
Stone Crab	Fall	01	9.50
		02	15.50
		03	11.50
		04	12.00
		06	14.50
		07	4.00
		08	8.00
	Summer	C1	4.67
		C2	6.33
		C3	7.33
		C4	8.67
		01	5.67
		02	13.33
		03	12.33
		04	7.33
		05	9.00
		06	12.00
		07	2.67
		08	6.67
	Winter	01	2.50
		02	3.33
		03	4.00
		04	2.00
		05	3.00
		07	1.00
		08	2.00
Belted Sandfish	Fall	01	4.00
		02	2.00
		03	1.50
		04	1.00
	Summer	C1	2.00
		C2	2.00
		C3	3.00
		C4	1.00
		03	1.33
		05	0.33
		08	1.33
Whitespotted Soapfish	Summer	04	0.33
Sheepshead	Fall	03	1.00
		08	1.00
	Summer	C2	0.33

Table 8 . (cont'd)

Taxa	Season	Station*	Number/m^2
Sheepshead	Summer	01	1.33
		02	0.33
		04	1.33
		05	1.33
		06	1.33
		07	0.89
		08	3.11
Sergeant Major	Fall	01	3.00
		03	1.00
		06	2.00
	Summer	C3	0.67
Cocoa Damselfish	Fall	01	1.00
		02	5.00
		03	5.00
		04	2.00
		06	6.00
		07	2.00
		08	4.00
	Summer	C1	1.00
		01	3.67
		02	1.67
		03	2.33
		04	3.33
		05	1.67
		06	3.67
		07	1.78
		08	6.22
Blenny (several species)	Fall	01	36.00
		02	27.00
		03	48.00
		04	26.50
		06	54.00
		07	33.00
		08	52.00
	Summer	C1	35.33
		C2	28.00
		C3	30.33
		C4	33.67
		01	58.00
		02	38.33
		03	39.67
		04	31.00
		05	37.33
		06	50.33
		07	40.44
		08	43.56

Table 8. (cont'd)

Taxa	Season	Station*	Number/m^2
Blenny (several species)	Winter	01	16.00
		02	18.67
		03	21.67
		04	25.00
		05	20.00
		06	43.00
		07	35.00
		08	16.00

*See Table 14 for Station Locations.

Table 9. Average density (number/m^3) of fish observed by underwater camera in the 1977-78 Buccaneer Oil Field Study Area.

Date	Station*	Depth (ft)	Time Start-end	Number of Observations	% of observations with no fish	Species	Average number/m^3
09/20/77	C2	40	1204-1834	73	64.4	Unidentified	0.0023
						Blue runner	0.0007
						Sheepshead	0.0007
						Atlantic spadefish	0.0006
	C3	60	1204-1828	71	100.0	-	-
	N1	15	1347-1705	33	54.3	Unidentified	0.0018
						Atlantic moonfish	0.0007
						Sheepshead	0.0014
	N2	40	1347-1705	33	87.9	Atlantic moonfish	0.0184
						Atlantic spadefish	0.0023
	N3	60	1347-1711	34	94.1	Unidentified	0.0003
						Sheepshead	0.0003
09/21/77	C1	15	1404-1842	50	98.0	Atlantic spadefish	0.0006
	C2	40	1404-1859	53	86.8	Unidentified	0.0002
						Sheepshead	0.0006
						Atlantic spadefish	0.0001
	C3	60	1404-1848	53	92.5	Unidentified	0.0006
						Sheepshead	0.0006
						Atlantic spadefish	0.0012
	D1	15	1020-1831	73	100.0	-	-
	D2	40	1027-1341	28	65.5	Unidentified	0.0031
						Atlantic spadefish	0.0026

Table 9 . (cont'd)

Date	Station *	Depth (ft)	Time Start-end	Number of Observations	% of observations with no fish	Species	Average number/m^3
09/21/77	D3	60	1020-1838	72	100.0	-	-
09/22/77	C1	15	0700-1131	46	13.0	Unidentified	0.0176
						Atlantic spadefish	0.0003
						Great barracuda	0.0005
	C2	40	0700-1031	35	74.3	Unidentified	0.0011
						Sheepshead	0.0003
						Atlantic spadefish	0.0002
	C3	60	0700-1055	40	85.0	Unidentified	0.012
						Sheepshead	0.0011
						Atlantic spadefish	0.0047
10/18/77	C1	15	1400-1853	51	49.0	Unidentified	0.0024
						Sheepshead	0.0012
						Atlantic spadefish	0.0040
	C2	40	1400-1841	49	61.2	Unidentified	0.0004
						Sheepshead	0.0019
						Atlantic spadefish	0.0048
						Gray triggerfish	0.0002
	C3	60	1400-1847	50	56.0	Unidentified	0.0027
						Sheepshead	0.0044
						Atlantic spadefish	0.0080
	N1	15	1420-1850	43	69.8	Sheepshead	0.0046
	N2	40	1420-1844	42	76.2	Unidentified	0.0011
						Sheepshead	0.0029
						Atlantic spadefish	0.0004

Table 9. (cont'd)

Date	Station *	Depth (ft)	Time Start-end	Number of Observations	% of observations with no fish	Species	Average number/m^3
	N3	60	1420-1844	42	95.2	Unidentified	0.0003
						Atlantic spadefish	0.0003
10/19/77	C1	15	0827-1251	49	71.4	Unidentified	0.0026
						Blue runner	0.0001
						Tomtate	0.0001
						Sheepshead	0.0002
						Atlantic spadefish	0.0030
	C2	40	0827-1319	54	35.2	Unidentified	0.0161
						Blue runner	0.0024
						Tomtate	0.0032
						Pinfish	0.0018
						Atlantic spadefish	0.0065
	C3	60	0827-1302	51	68.6	Unidentified	0.0004
						Sheepshead	0.0046
						Atlantic spadefish	0.0041
	N1	15	0823-1355	56	71.4	Unidentified	0.0009
						Sheepshead	0.0013
						Atlantic spadefish	0.0013
	N2	40	0823-1426	60	76.7	Unidentified	0.0005
						Sheepshead	0.0044
						Atlantic spadefish	0.0007
	N3	60	0823-1420	59	100.0	-	-

Table 9 . (cont'd)

Date	Station*	Depth (ft)	Time Start-end	Number of Observations	% of observations with no fish	Species	Average number/m^3
11/13/77	C1	15	1505-1704	22	63.6	Unidentified	0.0053
						Blue runner	0.0495
	C2	40	1505-1707	22	9.1	Unidentified	0.0010
						Pinfish	0.2436
	C3	60	1505-1704	22	72.7	Unidentified	0.0288
						Sheepshead	0.0035
						Atlantic spadefish	0.0022
	D1	15	1535-1723	16	68.8	Unidentified	0.0018
						Atlantic spadefish	0.0047
	D2	40	1535-1715	15	46.7	Unidentified	0.0032
						Atlantic spadefish	0.0178
						Gray triggerfish	No est.
	D3	60	1535-1723	16	75.0	Unidentified	0.0049
						Atlantic spadefish	0.0020
						Gray triggerfish	0.0059
11/14/77	C1	15	0730-1246	51	96.1	Sheepshead	0.0003
						Atlantic spadefish	0.0003
	C2	40	0730-1252	52	82.7	Unidentified	0.0016
						Sheepshead	0.0047
	C3	60	0730-1252	52	90.4	Sheepshead	0.0074

Table 9. (cont'd)

Date	Station*	Depth (ft)	Time Start-end	Number of Observations	% of observations with no fish	Species	Average number/m^3
11/14/77	D1	15	0753-1143	34	93.9	Atlantic spadefish	0.0016
	D2	40	0753-1150	34	97.1	Sheepshead	0.0005
	D3	60	0753-1143	33	100.0	-	-
02/27/78	C1	15	1100-1633	49	95.9	Sheepshead	0.0102
	C2	40	1100-1633	49	93.9	Sheepshead	0.0204
	C3	60	1100-1626	48	95.8	Unidentified Sheepshead	0.0016 0.0016
	D1	15	1130-1706	55	100.0	-	-
	D2	40	1130-1725	58	91.4	Sheepshead	0.0216
	D3	60	1130-1437	31	68.8	Sheepshead Atlantic spadefish	0.0081 0.0887

*See Table 14 for Station locations.

Table 10. Weight (g) and number of blennies collected by air lift during the Buccaneer Oil Field Study.

Date	Station*	*Blennius marmoreus* weight (g)	*Blennius marmoreus* number	*Hypleurochilus geminatus* weight (g)	*Hypleurochilus geminatus* number
2/28/78	BD1	35.2	1	268.8	9
	BD2	168.9	5	227.5	17
	BD3	20.3	1	4.0	1
2/28/78	BN1	0.0	0	87.4	4
	BN2	207.5	11	518.5	22
	BN3	208.4	7	31.7	3
3/10/78	CS1	49.1	1	352.7	10
	CS2	60.8	1	145.0	4
	CS3	5.6	2	26.6	2

*See Table 14 for Station locations.

Table 11. Summary of length-weight relationship differences for *Hypleurochilus geminatus* during summer 1977.

Station[b]	Males Length (mm) Min.	Males Length (mm) Max.	Males No.	Females Length (mm) Min.	Females Length (mm) Max.	Females No.	Test Results[a]
Platform A discharge	51	69	4	-	-	0	no test
Platform A non-discharge	48	95	63	45	60	14	n.s.
Flare Stack A	57	96	25	60	83	8	n.s.
Control B satellite	48	107	57	44	90	14	n.s.

[a] n.s. = not significant at $\alpha = 0.05$.

[b] There was no significant difference between stations for either sex.

Table 12. Summary of length-weight relationship differences for *Blennius marmoreus* during summer 1977.

Station[b]	Males Length (mm) Min.	Males Length (mm) Max.	Males No.	Females Length (mm) Min.	Females Length (mm) Max.	Females No.	Test Results[a]
Platform A discharge	48	70	10	52	80	19	n.s.

[a] n.s. = not significant at $\alpha = 0.05$.

[b] *B. marmoreus* were only collected at one station during summer.

Table 13. Summary of length-weight relationship differences for blennies collected during summer 1977.

Species	Contrast	Within	Test Results[a]
Hypleurochilus geminatus	Males vs Females	Platform A discharge	No test[b]
		Platform A non-discharge	n.s.
		Flare Stack A	n.s.
		Control B satellite	n.s.
	Between structures	Females	n.s.
		Males	n.s.
Blennius marmoreus	Males vs Females	Platform A discharge[c]	n.s.

[a] n.s. = not significant at $\alpha = 0.05$

[b] no females collected

[c] only collected at one station during summer

Table 14. List of Stations and their locations by gear type.

Gear	Date	Station	Platform*	Latitude**	Longitude**
Trawl	051376	1X	-	285612	943806
	051376	2X	-	285556	943906
	051376	3X	-	285542	943736
	051476	1Y	-	284906	944418
	051476	2Y	-	284802	944354
	051476	4X	-	285524	943712
	051576	1P	-	285054	944148
	051576	2P	-	285212	944151
	051576	3P	-	285342	944109
	051576	3Y	-	284824	944536
	051576	4P	-	285212	944142
	051576	4Y	-	284912	944542
	051576	5P	-	285045	944133
	051576	5Y	-	285042	944712
	051576	6Y	-	284918	944406
	051676	10P	-	285212	944103
	051676	11P	-	285106	944118
	051676	12P	-	285103	944212
	051676	13P	-	285230	944230
	051676	14P	-	285351	944218
	051676	6P	-	281518	944254
	051676	7P	-	285233	944242
	051676	8P	-	285409	944154
	051676	9P	-	285357	944112
	080976	1X	-	285606	943854
	080976	2X	-	285548	943812
	080976	3X	-	285457	943630
	081076	1P	-	285124	944148
	081076	2P	-	285330	944224
	081076	3P	-	285406	944212
	081176	1Y	-	285048	944624
	081176	2Y	-	284930	944606
	081176	3Y	-	284901	944512
	081176	4P	-	285348	944106
	111576	1P	-	285230	944152
	111576	2P	-	285230	944152
	111576	3P	-	285230	944152
	111576	4P	-	285230	944152
	111776	1Y	-	284921	944514
	111776	2Y	-	284921	944514
	111776	3Y	-	284921	944514
	111876	1X	-	285536	943724
	111876	2X	-	285536	943724
	111876	3X	-	285536	943724
	111976	4X	-	285536	943724
	021577	1X	-	285536	943724

Table 14.(cont'd)

Gear	Date	Station	Platform*	Latitude**	Longitude**
Trawl	021577	2X	-	285536	943724
	021577	3X	-	285536	943724
	021677	1P	-	295230	944152
	021677	2P	-	285230	944152
	021677	3P	-	285230	944152
	021677	4P	-	285230	944152
	021677	4X	-	285536	943724
	021777	1Y	-	284921	944514
	021777	2Y	-	284921	944514
	021777	3Y	-	284921	944514
	021777	4Y	-	284921	944514
	101877	AE	-	285330	944142
	101877	AN	-	285330	944142
	101877	AS	-	285330	944142
	101877	AW	-	285330	944142
	101877	BN	-	285216	944149
	101877	BS	-	285216	944149
	101877	CE	-	285400	944116
	101877	CN	-	285400	944116
	101877	CS	-	285400	944116
	101877	CW	-	285400	944116
	101877	IS	-	285201	944151
	031078	AN	-	285330	944142
	031078	AS	-	285330	944142
	031078	BE	-	285216	944149
	031078	BN	-	285216	944149
	031078	BS	-	285216	944149
	031078	BW	-	285216	944149
	031078	CE	-	285400	944116
	031078	CN	-	285400	944116
	031078	CS	-	285400	944116
	031078	CW	-	285400	944116
Trapnet	051676	1P	-	285230	944152
	051776	1Y	-	284921	944514
	051876	1X	-	285536	943724
	080976	1X	-	285536	943724
	081076	1P	-	285230	944152
	081176	1Y	-	284921	944514
	111576	1P	-	285230	944152
	111776	1Y	-	284921	944514
	111876	1X	-	285536	943724
	021676	1P	-	285230	944152
	111576	2P	-	285230	944152
	111776	2Y	-	284921	944514
	111876	2X	-	285536	943724

Table 14.(cont'd)

Gear	Date	Station	Platform*	Latitude**	Longitude**
Trapnet	021577	2X	-	285536	943724
	021677	2P	-	2855230	944152
	081677	A1	-	285330	944142
	081677	A2	-	285330	944142
	081677	A3	-	285330	944142
	081677	C1	-	285400	944116
	081677	C2	-	295400	944116
	081677	C3	-	285400	944116
	102577	A1	-	285330	944142
	102577	A2	-	285330	944142
	102577	A3	-	285330	944142
	102577	C1	-	285400	944116
	102577	C2	-	285400	944116
	102577	C3	-	285400	944116
	102677	NA3	-	285330	944142
	102777	DA3	-	285330	944142
	022378	B2	-	285216	944149
	022378	B3	-	285216	944149
	022378	C2	-	285400	944116
	022378	C3	-	285400	944116
Longline	080476	25	-	285450	944056
	080476	26	-	285450	944056
	083176	22	-	285256	944220
	083176	27	-	285415	944020
	092376	26	-	285450	944056
	092376	52	-	285424	943921
	092376	7	-	285217	944119
	092476	25	-	285450	944138
	092476	51	-	285550	943921
	092476	6	-	285225	944119
Trolling	060976	H2	-	285241	944149
	060976	I1	-	285201	944151
	060976	03	-	285050	944136
	060976	11	-	285117	944119
	060976	36	-	284950	944126
	060976	60	-	284850	944113
	061176	A	-	285355	944153
	061176	F	-	285326	944110
	061176	L	-	285216	944149
	061176	18	-	285215	944220
	061176	29	-	285301	944020
	061176	66	-	285154	944420
	080276	K	-	285156	944228
	080276	LA	-	285216	944149
	080276	03	-	285305	944119

Table 14.(cont'd)

Gear	Date	Station	Platform*	Latitude**	Longitude**
Trolling	080276	27	-	285415	944020
	080276	34	-	285033	944020
	080276	61	-	284850	944113
	080476	FA	-	285326	944110
	080476	FB	-	285326	944110
	080476	LA	-	285216	944149
	080476	18	-	285215	944220
	080476	68	-	285314	944420
	080576	DA	-	285330	944142
	080576	FA	-	285326	944110
	080576	FB	-	285326	944110
	080576	11	-	285117	944119
	080576	42	-	285205	944320
	080576	49	-	285550	944131
	080676	EA	-	285330	944131
	080676	HC	-	285241	944119
	080676	LA	-	285216	944149
	080676	41	-	285138	944320
	080676	63	-	284850	944420
	080676	8	-	285209	944119
	091276	E6	-	285330	944131
	091276	L9	-	285216	944149
	091276	28	-	285335	944020
	091276	6	-	295225	944119
	091276	67	-	285234	944420
	110176	DA	-	285330	944142
	110176	EA	-	285330	944131
	110176	23	-	285324	944220
	110176	27	-	285415	944020
	110176	72	-	285550	944227
	110676	LA	-	285216	944149
	110676	06	-	285255	944134
	110676	07	-	285217	944119
	110676	25	-	285450	944138
	110676	71	-	285550	944329
	112376	DA	-	285330	944142
	112376	FA	-	285326	944110
	112376	33	-	285107	944020
	112376	53	-	285329	943921
	112376	6	-	285225	944119
	120376	HA	-	285241	944119
	120376	LA	-	285216	944149
	120376	06	-	295225	944119
	120376	40	-	295105	944320
	120376	54	-	295246	943921
	121676	DA	-	285330	944131
	121676	IA	-	285201	944151

Table 14.(cont'd)

Gear	Date	Station	Platform*	Latitude**	Longitude**
Trolling	121676	26	-	285450	944056
	121676	34	-	285033	944020
	121676	72	-	285550	944227
	121776	DA	-	285330	944142
	121776	JA	-	285219	944058
	121776	27	-	285415	944020
	121776	3	-	285305	944118
	121776	72	-	285550	944227
	012177	BA	-	285400	944116
	012177	LA	-	285216	944149
	012177	4	-	285246	944119
	012177	48	-	285450	944218
	912177	63	-	284850	944420
	021377	JA	-	285219	944058
	021377	LA	-	285216	944149
	021377	1	-	285350	944143
	021377	41	-	285138	944320
	021377	62	-	284850	944307
	030777	IA	-	285201	944151
	030777	LA	-	285216	944149
	030777	29	-	285301	944020
	030777	3	-	285305	944119
	030777	54	-	285246	943921
Gillnet	080476	20	-	285230	944220
	080676	F	-	285230	944110
	080676	27	-	285415	944020
Airlift	022878	BD1	-	285216	944149
	022878	BD2	-	285216	944149
	022878	BD3	-	285216	944149
	022878	BN1	-	285216	944149
	022878	BN2	-	285216	944149
	022878	BN3	-	285216	944149
	031078	CS1	-	285400	944116
	031078	CS2	-	285400	944116
	031078	CS3	-	285400	944116
Underwater Camera					
	092077	C2	JCKT C	-	-
	092077	C3	JCKT C	-	-
	092077	N1	PLTF AP	-	-
	092077	N2	PLTF AP	-	-
	092077	N3	PLTF AP	-	-
	092177	C1	JCKT C	-	-
	092177	C2	JCKT C	-	-
	092177	C3	JCKT C	-	-
	092177	DI	PLTF AP	-	-

Table 14.(cont'd)

Gear	Date	Station	Platform*	Latitude**	Longitude**
Underwater Camera					
	092177	DS	PLTF AP	-	-
	092277	C1	JCKT C	-	-
	092277	C2	JCKT C	-	-
	092277	60	JCKT C	-	-
	101877	C1	JCKT C	-	-
	101877	C2	JCKT C	-	-
	101877	C3	JCKT C	-	-
	101877	N1	PLTF AP	-	-
	101877	N2	PLTF AP	-	-
	101877	N3	PLTF AP	-	-
	101977	C1	JCKT C	-	-
	101977	C2	JCKT C	-	-
	101977	C3	JCKT C	-	-
	101977	N1	PLTF AP	-	-
	101977	N2	PLTF AP	-	-
	101977	N3	PLTF AP	-	-
	111377	C2	JCKT C	-	-
	111377	C3	JCKT C	-	-
	111377	D1	PLTF BP	-	-
	111377	D2	PLTF BP	-	-
	111377	D3	PLTF BP	-	-
	111477	C1	JCKT C	-	-
	111477	C2	JCKT C	-	-
	111477	C3	JCKT C	-	-
	111477	D1	PLTF B	-	-
	111477	D2	PLTF B	-	-
	111477	D3	PLTF BP	-	-
	022778	C1	JCKT C	-	-
	022778	C2	JCKT C	-	-
	022778	C3	JCKT C	-	-
	022778	D1	PLTF BP	-	-
	022778	D2	PLTF BP	-	-
	022778	D3	PLTF BP	-	-
	111378	C1	JCKT C	-	-
Diver Observation					
	081177	C1	JCKT I	-	-
	081177	C2	JCKT I	-	-
	081177	C3	JCKT I	-	-
	081177	C4	JCKT I	-	-
	081177	01	PLTF AP	-	-
	081177	02	PLTF AP	-	-
	081177	03	PLTF AP	-	-
	081177	04	PLTF AP	-	-
	081177	05	PLTF AP	-	-

Table 14.(cont'd)

Gear	Date	Station	Platform*	Latitude**	Longitude**
Diver Observation					
	081177	06	PLTF AP	-	-
	081177	07	PLTF AP	-	-
	081177	08	PLTF AP	-	-
	102077	01	PLTF	-	-
	102077	01	PLTF AP	-	-
	102077	02	JCKT I	-	-
	102077	02	PLTF AP	-	-
	102077	03	JCKT I	-	-
	102077	03	PLTF AP	-	-
	102077	04	JCKT I	-	-
	102077	04	PLTF AP	-	-
	102077	06	PLTF AP	-	-
	102077	06	PLTF AP	-	-
	102077	07	PLTF AP	-	-
	102077	08	PLTF AP	-	-
	020578	01	PLTF BP	-	-
	020578	02	PLTF BP	-	-
	020578	03	PLTF BP	-	-
	020578	04	PLTF BP	-	-
	020578	05	PLTF BP	-	-
	020578	06	PLTF BP	-	-
	020578	07	PLTF BP	-	-
	020578	08	PLTF BP	-	-
	022478	01	JCKT I	-	-
	022478	01	PLTF AP	-	-
	022478	02	JCKT I	-	-
	022478	02	PLTF AP	-	-
	022478	03	JCKT I	-	-
	022478	03	PLTF AP	-	-
	022478	04	JCKT I	-	-

* PLTF = Platform
JCKT = Well Jacket
AP = 288A Production
BP = 296B Production

**Where appropriate.

Table 15. Stomach contents of fish collected at station A during summer in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Sardinella aurita	2	Unidentifiable plant matter	1	50
		Empty stomach	1	50
Decapturus punctatus	3	Unidentifiable adult penaeid shrimp	1	33
		Unidentifiable crustacean remains	1	33
		Unidentifiable animal matter	3	100
Lutjanus campechanus	4	Unidentifiable crustacean remains	1	25
		Unidentifiable fish remains	4	100
		Unidentifiable animal matter	3	75
Haemulon aurolineatum	17	Unidentifiable nematode	1	6
		Creseis acicula	1	6
		Unidentifiable crustacean remains	1	6
		Unidentifiable fish remains	3	18
		Unidentifiable animal matter	17	100
Orthopristis chrysopterus	2	Unidentifiable crustacean remains	1	6
		Unidentifiable fish remains	1	6
		Unidentifiable animal matter	2	12
Equetus umbrosus	4	Barnacle remains	2	50
		Unidentifiable adult penaeid shrimp	1	25
		Unidentifiable portunid crab remains	1	25
		Unidentifiable crustacean remains	2	50
		Unidentifiable fish remains	2	50
		Unidentifiable animal matter	4	100

Table 15.(cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Lagodon rhomboides	1	Unidentifiable animal matter	1	100
Archosargus probatocephalus	3	*Bugula neritina*	2	67
		Barnacle remains	2	67
		Alpheus floridanus	1	33
		Unidentifiable portunid crab remains	1	33
		Unidentifiable animal matter	1	100
		Unidentifiable plant matter	1	33
Kyphosus sectatrix	1	Algae	1	100
		Unidentifiable nematode	1	100
		Stomattopod zoea	1	100
		Unidentifiable plant matter	1	100
Chaetodipterus faber	7	Algae	1	14
		Class Rhodophyta	3	43
		Unidentifiable nematode	1	14
		Barancle remains	1	14
		Unidentifiable adult penaeid shrimp	1	14
		Unidentifiable ophiuroid fragments	1	14
		Unidentifiable fish remains	3	43
		Unidentifiable animal matter	4	57
		Unidentifiable plant matter	4	57
Blennius marmoreus	6	Class Rhodophyta	1	17
		Class Chlorophyta	1	17
		Unidentifiable nematode	1	17
		Plastic spheres	2	33
		Unidentifiable plant matter	6	100
Hypleurochilus geminatus	96	Class Rhodophyta	36	38
		Order Nemaliales	4	4
		Adquinella sp.	21	22

Table 15. (cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Hypleurochilus geminatus		Order Ceramiales	1	1
		Antithamnion sp.	12	13
		Class Chlorophyta	39	41
		Cladophora sp.	18	19
		Phylum Cnidaria	1	1
		Unidentifiable hydroid fragment	1	1
		Unidentifiable nematode	13	14
		Creseis acicula	45	47
		Unidentifiable polychaete remains	2	2
		Unidentifiable ostracod	2	2
		Barnacle remains	18	19
		Unidentifiable harpacticoid copepod	2	2
		Elasmopus rapay	1	1
		Podocerus brasiliensis	5	5
		Unidentifiable amphipod fragment	3	3
		Tanais cavolini	2	2
		Unidentifiable zoea penaeid shrimp	1	1
		Unidentifiable decapod remains	5	5
		Unidentifiable crustacean remains	3	3
		Unidentifiable ophiuroid fragments	2	2
		Unidentifiable fish remains	11	11
		Unidentifiable plant matter	89	93
Balistes capriscus	1	Unidentifiable crustacean remains	1	100
		Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100

Table 16. Stomach contents of fish collected at station C during summer in the 1977-78 Buccanner Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomach with Item
Rypticus maculatus	1	Unidentifiable animal matter	1	100
Lutjanus campechanus	15	Unidentifiable nematode	2	13
		Creseis acicula	1	7
		Unidentifiable polychaete remains	1	7
		Squilla empusa	1	7
		Stomattopod zoea	2	13
		Unidentifiable amphipod fragment	1	7
		Unidentifiable adult penaeid shrimp	1	7
		Unidentifiable crustacean remains	4	27
		Unidentifiable crab zoea	1	7
		Unidentifiable fish remains	13	87
		Unidentifiable animal matter	14	93
Haemulon aurolineatum	51	Class Chlorophyta	2	4
		Unidentifiable nematode	12	24
		Creseis acicula	5	10
		Unidentifiable gastropod remains	1	2
		Unidentifiable bivalve remains	1	2
		Barnacle remains	3	6
		Corophium acherusicum	1	2
		Unidentifiable postlarva penaeid shrimp	3	6
		Unidentifiable brachyuran remains	3	6
		Unidentifiable xanthid crab remains	3	6

Table 16.(cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Haemulon aurolineatum		Unidentifiable crustacean remains	3	6
		Unidentifiable fish remains	15	29
		Unidentifiable animal matter	50	98
Equetus umbrosus	10	Unidentifiable nematode	2	20
		Barnacle remains	1	10
		Stomattopod zoea	1	10
		Alpheus sp.	1	10
		Unidentifiable fish remains	5	50
		Unidentifiable animal matter	10	100
Archosargus probatocephalus	2	Algae	2	100
		Barnacle remains	1	50
		Alpheus sp.	1	50
		Unidentifiable fish remains	1	50
Kyphosus incisor		Algae	1	100
		Unidentifiable plant matter	1	100
Chaetodipterus faber	3	Algae	1	33
		Unidentifiable nematode	1	33
		Barnacle remains	2	67
		Stomattopod zoea	2	67
		Elasmopus levis	1	33
		Unidentifiable postlarva penaeid shrimp	1	33
		Unidentifiable zoea penaeid shrimp	1	33
		Unidentifiable portunid crab remains	1	33
		Unidentifiable crustacean remains	1	33
		Unidentifiable fish remains	1	33
		Unidentifiable animal matter	3	100
		Unidentifiable plant matter	2	67

Table 16 (cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Hypleurochilus geminatus	67	Class Rhodophyta	54	81
		Class Chlorophyta	56	84
		Creseis acicula	22	33
		Unidentifiable ostracod	1	1
		Barnacle remains	9	13
		Elasmopus rapay	1	1
		Grandidierella bonnieroides	1	1
		Unidentifiable amphipod fragment	1	1
		Unidentifiable caridean shrimp	2	3
		Callianassa sp.	1	1
		Unidentifiable xanthid crab remains	1	1
		Unidentifiable decapod remains	5	7
		Unidentifiable fish remains	4	6
		Plastic spheres	1	1
		Unidentifiable plant matter	64	96
Balistes capriscus	1	Unidentifiable fish remains	1	100

Table 17. Stomach contents of fish collected at station A during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	5	Class Rhodophyta	2	40
		Unidentifiable portunid crab remains	3	60
		Bettle elytra	1	20
		Unidentifiable fish remains	5	100
		Unidentifiable animal matter	5	100
Rypticus maculatus	3	Unidentifiable fish remains	1	33
		Unidentifiable animal matter	3	100
Lutjanus campechanus	2	Unidentifiable nematode	1	50
		Unidentifiable crustacean remains	1	50
		Unidentifiable fish remains	2	100
		Plastic spheres	1	50
		Unidentifiable animal matter	2	100
Haemulon aurolineatum	1	Unidentifiable animal matter	1	100
Orthopristis chrysopterus	2	Class Chlorophyta	1	50
		Unidentifiable fish remains	1	50
		Unidentifiable animal matter	2	100
Equetus umbrosus	1	Unidentifiable animal matter	1	100

Table 18. Stomach contents of fish collected at station AE during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	33	Unidentifiable tapeworm	1	3
		Unidentifiable nematode	1	3
		Unidentifiable gastropod remains	1	3
		Family Phyllodocidae	1	3
		Ampelisca sp.	2	6
		Mysidopis bigelowi	1	3
		Trachypeneus similis	1	3
		Unidentifiable adult penaeid shrimp	5	15
		Leptochela serratorbita	5	15
		Unidentifiable portunid crab remains	7	21
		Unidentifiable decapod remains	11	33
		Plastic spheres	4	12
		Pebbles	2	6
		Unidentifiable animal matter	33	100
Lutjanus campechanus	3	*Squilla empusa*	1	33
		Unidentifiable postlarva penaeid shrimp	1	33
		Unidentifiable xanthid crab remains	1	33
		Unidentifiable animal matter	3	100

Table 19. Stomach contents of fish collected at station AN during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	125	Algae	1	1
		Unidentifiable nematode	2	2
		Cantharus cancellarius	1	1
		Unidentifiable castropod remains	3	2
		Unidentifiable polychaete remains	1	1
		Squilla empusa	2	2
		Ampelisca sp.	2	2
		Trachypeneus similis	1	1
		Unidentifiable adult penaeid shrimp	11	9
		Unidentifiable postlarva penaeid shrimp	2	2
		Leptochela serratorbita	1	1
		Petrochirus diogenes	1	1
		Calappa sp.	1	1
		Unidentifiable portunid crab remains	2	2
		Unidentifiable decapod remains	2	2
		Unidentifiable crustacean remains	3	2
		Class Holothuroidea	2	2
		Unidentifiable fish remains	29	23
		Plastic spheres	3	2
		Unidentifiable animal matter	125	100
Lutjanus campechanus	1	Unidentifiable postlarva penaeid shrimp	1	100
		Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100

Table 19,(cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Haemulon aurolineatum	1	Unidentifiable postlarva penaeid shrimp	1	100
		Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100
Micropogon undulatus	1	Unidentifiable postlarva penaeid shrimp	1	100
		Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100
Syacium gunteri	9	Unidentifiable nematode	1	11
		Unidentifiable polychaete remains	1	11
		Ampelisca agassizi	1	11
		Trachypeneus similis	1	11
		Unidentifiable adult penaeid shrimp	2	22
		Unidentifiable postlarva penaeid shrimp	3	33
		Persephona crinata	1	11
		Unidentifiable portunid crab remains	1	11
		Unidentifiable animal matter	7	78

Table 20. Stomach contents of fish collected at station AS during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	20	Unidentifiable nematode	5	25
		Unidentifiable bivalve remains	1	5
		Unidentifiable polychaete remains	4	20
		Ampelisca verrilli	1	5
		Ampelisca sp.	3	15
		Unidentifiable amphipod fragment	1	5
		Unidentifiable adult penaeid shrimp	4	20
		Unidentifiable postlarva penaeid shrimp	2	10
		Leptochela serratorbita	1	5
		Petrochirus diogenes	1	5
		Unidentifiable portunid crab remains	2	10
		Unidentifiable fish remains	12	60
		Plastic spheres	2	10
		Unidentifiable animal matter	19	95
		Empty stomach	1	5
Lutjanus campechanus	2	Unidentifiable animal matter	2	100
Haemulon aurolineatum	1	Unidentifiable postlarva penaeid shrimp	1	100
		Unidentifiable animal matter	1	100

Table 21. Stomach contents of fish collected at station AW during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	80	Algae	1	1
		Unidentifiable nematode	4	5
		Unidentifiable gastropod remains	1	1
		Lumbrineris tenuis	1	1
		Paraprionospio pinnata	1	1
		Unidentifiable polychaete remains	5	6
		Ampelisca verrilli	1	1
		Ampelisca sp.	1	1
		Unidentifiable amphipod fragment	1	1
		Unidentifiable adult penaeid shrimp	1	1
		Unidentifiable postlarva penaeid shrimp	5	6
		Hepatus pudibundis	1	1
		Unidentifiable portunid crab remains	1	1
		Unidentifiable decapod remains	1	1
		Unidentifiable fish remains	16	20
		Plastic spheres	6	8
		Unidentifiable animal matter	80	100
		Unidentifiable plant matter	1	1
Lutjanus synagris	1	Unidentifiable postlarva penaeid shrimp	1	100
Syacium gunteri	5	*Nephthys* sp.	1	20
		Unidentifiable polychaete remains	1	20
		Ampelisca abdita	1	20

Table 21. (cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri		*Trachypeneus similis*	2	40
		Unidentifiable postlarva penaeid shrimp	1	20
		Unidentifiable portunid crab remains	1	20
		Spiocarcinus lobatus	1	20
		Unidentifiable animal matter	1	20

Table 22. Stomach contents of fish collected at station BN during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	16	Unidentifiable nematode	1	6
		Unidentifiable gastropod remains	1	6
		Unidentifiable polychaete remains	1	13
		Squilla empusa	1	6
		Ampelisca sp.	4	25
		Caprella equilibra	1	6
		Mysidopis bigelowi	1	6
		Trachypeneus similis	1	6
		Unidentifiable adult penaeid shrimp	2	13
		Leptochela serratorbita	3	19
		Unidentifiable fish remains	7	44
		Plastic spheres	1	6
		Unidentifiable animal matter	15	94
Lutjanus campechanus	1	Unidentifiable postlarva penaeid shrimp	1	100
		Unidentifiable animal matter	1	100
Micropogon undulatus	7	Unidentifiable nematode	2	29
		Unidentifiable bivalve remains	3	43
		Lumbrineris tenuis	2	29
		Ampelisca verrilli	1	14
		Unidentifiable portunid crab remains	1	14
		Spiocarcinus lobatus	5	71
		Unidentifiable fish remains	2	29
		Unidentifiable animal matter	7	100
Syacium gunteri	11	Unidentifiable nematode	1	9
		Unidentifiable bivalve remains	1	9

Table 22.(cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri		*Ampelisca verrilli*	1	9
		Unidentifiable adult penaeid shrimp	1	9
		Unidentifiable postlarva penaeid shrimp	4	26
		Unidentifiable portunid crab remains	1	9
		Spiocarcinus lobatus	2	18
		Unidentifiable decapod remains	3	27
		Unidentifiable fish remains	4	36
		Unidentifiable animal matter	10	91
		Empty stomach	1	9

Table 23. Stomach contents of fish collected at station BS during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	7	Unidentifiable nematode	1	14
		Lumbrineris tenuis	1	14
		Ampelisca sp.	2	29
		Unidentifiable postlarva penaeid shrimp	1	14
		Unidentifiable crustacean remains	1	14
		Unidentifiable fish remains	1	14
		Unidentifiable animal matter	7	100
Lutjanus campechanus	5	*Ampelisca* sp.	1	20
		Trachypeneus similis	1	20
		Unidentifiable adult penaeid shrimp	2	40
		Unidentifiable postlarva penaeid shrimp	2	40
		Unidentifiable xanthid crab remains	1	20
		Unidentifiable fish remains	1	20
		Unidentifiable animal matter	5	100
Syacium gunteri	3	Unidentifiable polychaete remains	3	100
		Unidentifiable fish remains	1	33
		Unidentifiable animal matter	3	100

Table 24. Stomach contents of fish collected at station C during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Lutjanus campechanus	1	Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100
Haemulon aurolineatum	2	Unidentifiable fish remains	1	50
		Unidentifiable animal matter	2	100

Table 25. Stomach contents of fish collected at station CE during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	7	Unidentifiable nematode	2	29
		Unidentifiable polychaete remains	1	14
		Ampelisca sp.	1	14
		Unidentifiable adult penaeid shrimp	2	29
		Unidentifiable crustacean remains	1	14
		Unidentifiable fish remains	2	29
		Plastic spheres	1	14
		Unidentifiable animal matter	7	100
Lutjanus campechanus	1	Unidentifiable postlarva penaeid shrimp	1	100
		Unidentifiable animal matter	1	100
Lutjanus synagris	1	Unidentifiable adult penaeid shrimp	1	100
		Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100
Haemulon aurolineatum	6	Unidentifiable nematode	1	17
		Unidentifiable polychaete remains	1	17
		Ampelisca sp.	2	33
		Trachypeneus similis	1	17
		Unidentifiable adult penaeid shrimp	2	33
		Unidentifiable crustacean remains	1	17
		Unidentifiable fish remains	4	67
		Unidentifiable animal matter	4	83
		Empty stomach	1	17

Table 25. (cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	10	Unidentifiable nematode	1	10
		Lumbrineris tenuis	1	10
		Unidentifiable polychaete remains	3	30
		Ampelisca abdita	1	10
		Ampelisca sp.	5	50
		Mysidopis bigelowi	1	10
		Unidentifiable adult penaeid shrimp	3	30
		Alpheus sp.	1	10
		Unidentifiable portunid crab remains	1	10
		Unidentifiable decapod remains	1	10
		Unidentifiable fish remains	3	30
		Plastic spheres	1	10
		Unidentifiable animal matter	10	100

Table 26. Stomach contents of fish collected at station CN during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	10	Unidentifiable gastropod remains	1	10
		Glycera americana	1	10
		Nephthys sp.	1	10
		Lumbrineris tenuis	1	10
		Diopatra cuprea	1	10
		Unidentifiable polychaete remains	4	40
		Ampelisca sp.	1	10
		Unidentifiable adult penaeid shrimp	1	10
		Unidentifiable postlarva penaeid shrimp	2	20
		Unidentifiable portunid crab remains	2	20
		Unidentifiable crustacean remains	1	10
		Unidentifiable fish remains	1	10
		Unidentifiable animal matter	10	100
Syacium gunteri	13	*Nuculana concentrica*	2	15
		Unidentifiable polychaete remians	2	15
		Ampelisca abdita	1	8
		Ampelisca sp.	4	31
		Trachypeneus similis	1	8
		Unidentifiable adult penaeid shrimp	2	15
		Unidentifiable postlarva penaeid shrimp	2	15
		Persephona crinata	1	8
		Unidentifiable xanthid crab remains	1	8
		Unidentifiable animal matter	13	100

Table 27. Stomach contents of fish collected at station CS during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	6	*Glycera americana*	1	17
		Unidentifiable polychaete remains	2	33
		Ampelisca verrilli	1	17
		Ampelisca sp.	1	17
		Unidentifiable adult penaeid shrimp	1	17
		Unidentifiable portunid crab remains	1	17
		Spiocarcinus lobatus	1	17
		Unidentifiable ophiuroid	1	17
		fragments	1	17
		Unidentifiable fish remains	5	83
		Unidentifiable animal matter	6	100
Lutjanus campechanus	5	Unidentifiable nematod	1	20
		Unidentifiable polychaete remains	2	40
		Ampelisca verrilli	1	20
		Unidentifiable postlarva penaeid shrimp	4	80
		Spiocarcinus lobatus	1	20
		Unidentifiable fish remains	4	80
		Unidentifiable animal matter	5	100
		Unidentifiable plant matter	1	20
Syacium gunteri	18	Unidentifiable acanthocephalan	1	6
		Unidentifiable gastropod remains	1	6
		Unidentifiable bivalve remains	1	6
		Sthenelais boa	1	6
		Family Phyllodocidae	1	6

Table 27. (cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri		Family Maldanidae	1	6
		Terebellide stroemi	1	6
		Ampelisca abdita	1	6
		Ampelisca verrilli	3	17
		Ampelisca sp.	8	44
		Mysidopis bigelowi	1	6
		Trachypeneus similis	1	6
		Unidentifiable adult penaeid shrimp	1	6
		Unidentifiable postlarva penaeid shrimp	5	28
		Euceramus praelongus	1	6
		Unidentifiable brachyuran remains	1	6
		Persephona sp.	1	6
		Unidentifiable portunid crab remains	3	17
		Unidentifiable xanthid crab remains	1	6
		Spiocarcinus lobatus	1	6
		Pinnixa sayana	2	11
		Unidentifiable decapod remains	1	6
		Unidentifiable fish remains	1	6
		Unidentifiable animal matter	17	94
		Empty stomach	1	6

Table 28. Stomach contents of fish collected at station CW during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Examined	Contents	No. with Item	% Stomachs with Item
Arius felis	21	Unidentifiable nematode	2	10
		Unidentifiable polychaete remains	2	10
		Ampelisca agassizi	1	5
		Ampelisca sp.	2	10
		Unidentifiable adult penaeid shrimp	3	14
		Unidentifiable portunid crab remains	3	14
		Unidentifiable crustacean remains	1	5
		Unidentifiable fish remains	6	29
		Unidentifiable animal matter	20	95
		Empty stomach	1	5
Lutjanus campechanus	1	Unidentifiable adult penaeid shrimp	1	100
		Unidentifiable animal matter	1	100
Lutjanus synagris	1	Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100
Syacium gunteri	7	Unidentifiable nematode	2	29
		Trachypeneus similis	1	14
		Unidentifiable postlarva penaeid shrimp	3	43
		Leptochela serratorbita	1	14
		Unidentifiable portunid crab remains	2	29
		Unidentifiable xanthid crab remains	1	14
		Spiocarcinus lobatus	1	14
		Unidentifiable animal matter	6	86

Table 29. Stomach contents of fish collected at station IS during fall in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Lutjanus campechanus	7	Unidentifiable nematode	3	43
		Ampelisca sp.	1	14
		Trachypeneus similis	1	14
		Unidentifiable adult penaeid shrimp	2	29
		Unidentifiable postlarva penaeid shrimp	4	57
		Unidentifiable portunid crab remains	2	29
		Unidentifiable decapod remains	1	14
		Unidentifiable fish remains	3	43
		Unidentifiable animal matter	7	100
Lutjanus synagris	1	Unidentifiable adult penaeid shrimp	1	100
		Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100
Haemulon macrostomum	4	Unidentifiable polychaete remains	1	25
		Ampelisca sp.	2	50
		Unidentifiable adult penaeid shrimp	3	75
		Unidentifiable animal matter	3	75
		Empty stomach	1	25
Micropogon undulatus	17	Unidentifiable nematode	4	24
		Unidentifiable gastropod remains	3	18
		Lumbrineris tenuis	4	24
		Ampelisca verrilli	1	6
		Ampelisca sp.	1	6
		Unidentifiable postlarva penaeid shrimp	1	6
		Alpheus floridanus	1	6

Table 29. (cont'd)

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Micropogon undulatus		Unidentifiable portunid crab remains	1	6
		Unidentifiable xanthid crab remains	3	18
		Unidentifiable crustacean remains	1	6
		Unidentifiable ophiuroid fragments	2	12
		Unidentifiable fish remains	3	18
		Unidentifiable animal matter	16	94
		Empty stomach	1	6
Syacium gunteri	6	Unidentifiable nematode	3	50
		Unidentifiable polychaete	2	33
		remains	2	33
		Ampelisca verrilli	1	17
		Ampelisca sp.	1	17
		Unidentifiable adult penaeid shrimp	1	17
		Unidentifiable postlarva penaeid shrimp	4	67
		Unidentifiable fish remains	3	50
		Unidentifiable animal matter	6	100

Table 30. Stomach contents of fish collected at station AN during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Lutjanus campechanus	1	*Ampelisca* sp.	1	100
		Unidentifiable amphipod fragment	1	100
		Unidentifiable adult penaeid shrimp	1	100
		Unidentifiable animal matter	1	100
Syacium gunteri	2	Unidentifiable polychaete remains	1	50
		Ampelisca agassizi	1	50
		Caprella equilibra	1	50
		Grandidierella bonnieroides	1	50
		Jassa falcata	1	50
		Mysidopis bigelowi	1	50
		Oxyurostylis salinoi	1	50
		Unidentifiable adult penaeid shrimp	2	100
		Unidentifiable animal matter	2	100

Table 31. Stomach contents of fish collected at station AS during winter in the 1977-78 Buccaneer Oil Field Study.

Species	Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	6	Unidentifiable nematode	2	33
		Unidentifiable acanthocephalan	1	17
		Nephthys sp.	2	33
		Lumbrineris tenuis	1	17
		Unidentifiable polychaete remains	1	17
		Ampelisca verrilli	2	33
		Ampelisca sp.	4	67
		Caprella equilibra	1	17
		Unidentifiable amphipod fragment	1	17
		Trachypeneus similis	1	17
		Unidentifiable adult penaeid shrimp	1	17
		Unidentifiable postlarva penaeid shrimp	4	67
		Automate evermanni	1	17
		Euceramus praelongus	1	17
		Unidentifiable fish remains	1	17
		Unidentifiable animal matter	5	83

Table 32. **Stomach** contents of fish collected at station B during winter in the 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Lutjanus campechanus	1	Unidentifiable fish remains	1	100
		Unidentifiable animal matter	1	100
Equetus umbrosus	1	Unidentifiable gastropod remains	1	100
		Ampelisca sp.	1	100
		Unidentifiable animal matter	1	100

Table 33. Stomach contents of fish collected at station BE during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	11	Unidentifiable nematode	2	18
		Unidentifiable polychaete remains	2	18
		Ampelisca agassizi	2	18
		Ampelisca verrilli	1	9
		Ampelisca sp.	4	36
		Monoculodes edwardsi	1	9
		Unidentifiable postlarva penaeid shrimp	5	45
		Alpheus floridanus	1	9
		Unidentifiable decapod remains	1	9
		Unidentifiable fish remains	1	9
		Unidentifiable animal matter	10	91

Table 34. Stomach contents of fish collected at station BN during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Lutjanus campechanus	3	Unidentifiable nematode	1	33
		Mysidopis bigelowi	1	33
		Unidentifiable animal matter	3	100
Syacium gunteri	4	Unidentifiable nematode	1	25
		Sthenelais boa	1	25
		Unidentifiable polychaete remains	1	25
		Ampelisca verrilli	1	25
		Ampelisca sp.	1	25
		Unidentifiable adult penaeid shrimp	2	50
		Unidentifiable postlarva penaeid shrimp	2	50
		Automate evermanni	1	25
		Unidentifiable brachyuran remains	1	25
		Unidentifiable animal matter	4	100

Table 35. Stomach contents of fish collected at station BS during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	4	Unidentifiable acanthocephalan	1	25
		Ampelisca sp.	1	25
		Jassa falcata	1	25
		Sicyonia sp.	1	25
		Unidentifiable adult penaeid shrimp	1	25
		Leander sp.	1	25
		Unidentifiable animal matter	3	75

Table 36. Stomach contents of fish collected at station C during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	5	Unidentifiable polychaete remains	2	40
		Ampelisca agassizi	1	20
		Ampelisca verrilli	1	20
		Caprella equilibra	1	20
		Jassa falcata	2	40
		Mysidopis bigelowi	2	40
		Leptochela serratorbita	1	20
		Unidentifiable portunid crab remains	1	20
		Unidentifiable animal matter	4	80

Table 37. Stomach contents of fish collected at station BW during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Lutjanus campechanus	1	Unidentifiable amphipod fragment	1	100
		Unidentifiable animal matter	1	100
Equetus umbrosus	12	Unidentifiable nematode	2	17
		Barnacle remains	4	33
		Ampelisca sp.	3	25
		Caprella equilibra	3	25
		Corophium acherusicum	6	50
		Jassa falcata	2	17
		Stenothoe sp.	1	8
		Unidentifiable adult penaeid shrimp	1	8
		Alpheus floridanus	1	8
		Unidentifiable xanthid crab remains	2	17
		Unidentifiable crustacean remains	1	8
		Hemipholis elongata	1	8
		Micropholis atea	1	8
		Unidentifiable ophiuroid fragments	2	17
		Unidentifiable fish remains	2	17
		Unidentifiable animal matter	10	83

Table 38. Stomach contents of fish collected at station CE during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	17	Unidentifiable nematode	6	35
		Unidentifiable gastropod remains	1	6
		Lepidasthenia		
		Diopatra cuprea		
		Ampharetidae	2	12
		Unidentifiable polychaete remains	2	12
		Ampelisca verrilli	4	24
		Ampelisca sp.	4	24
		Mysidopis bigelowi	2	12
		Trachypeneus similis	1	6
		Unidentifiable adult penaeid shrimp	5	29
		Unidentifiable postlarva peneaid shrimp	1	6
		Alpheus floridanus	2	12
		Unidentifiable brachyuran remains	1	6
		Unidentifiable fish remains	2	12
		Unidentifiable animal matter	16	94

Table 39. Stomach contents of fish collected at station CN during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Items
Syacium gunteri	14	*Lumbrineris tenuis*	1	7
		Unidentifiable polychaete remains	5	36
		Ampelisca abdita	1	7
		Ampelisca agassizi	3	21
		Ampelisca verrilli	4	29
		Ampelisca sp.	5	36
		Caprella equilibra	3	21
		Corophium acherusicum	1	7
		Photis texensis	3	21
		Photis sp.	1	7
		Stenothoe sp.	1	7
		Unidentifiable amphipod fragment	1	7
		Trachypeneus similis		
		Unidentifiable adult penaeid shrimp	3	21
		Unidentifiable postlarva penaeid shrimp	3	21
		Automate evermanni		
		Unidentifiable animal matter	14	100

Table 40. Stomach contents of fish collected at station CS during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	13	Unidentifiable nematode	3	23
		Ampharetidae	1	8
		Ampelisca agassizi	1	8
		Ampelisca verrilli	2	15
		Ampelisca sp.	7	54
		Caprella equilibra	1	8
		Jassa falcata	1	8
		Unidentifiable adult penaeid shrimp	3	23
		Unidentifiable fish remains	2	15
		Unidentifiable animal matter	10	77
		Empty stomach	1	8

Table 41. stomach contents of fish collected at station CW during winter in 1977-78 Buccaneer Oil Field Study.

Species	Number Examined	Contents	No. with Item	% Stomachs with Item
Syacium gunteri	16	Unidentifiable nematode	3	18
		Armandia maculata	1	6
		Ampharetidae	1	6
		Ampharete acutifrons	2	13
		Unidentifiable polychaete remains	2	13
		Ampelisca abdita	1	6
		Ampelisca agassizi	1	6
		Ampelisca verrilli	2	13
		Ampelisca sp.	5	31
		Caprella equilibra	4	25
		Corophium acherusicum	1	6
		Jassa falcata	2	13
		Photis texensis	1	6
		Photis sp.	1	6
		Mysidopis bigelowi	3	19
		Unidentifiable adult penaeid shrimp	3	19
		Automate evermanni	1	6
		Alpheus floridanus	1	6
		Unidentifiable portunid crab remains	1	6
		Unidentifiable decapod remains	2	13
		Unidentifiable fish remains	2	13
		Unidentifiable animal matter	15	94
		Empty stomach	1	6

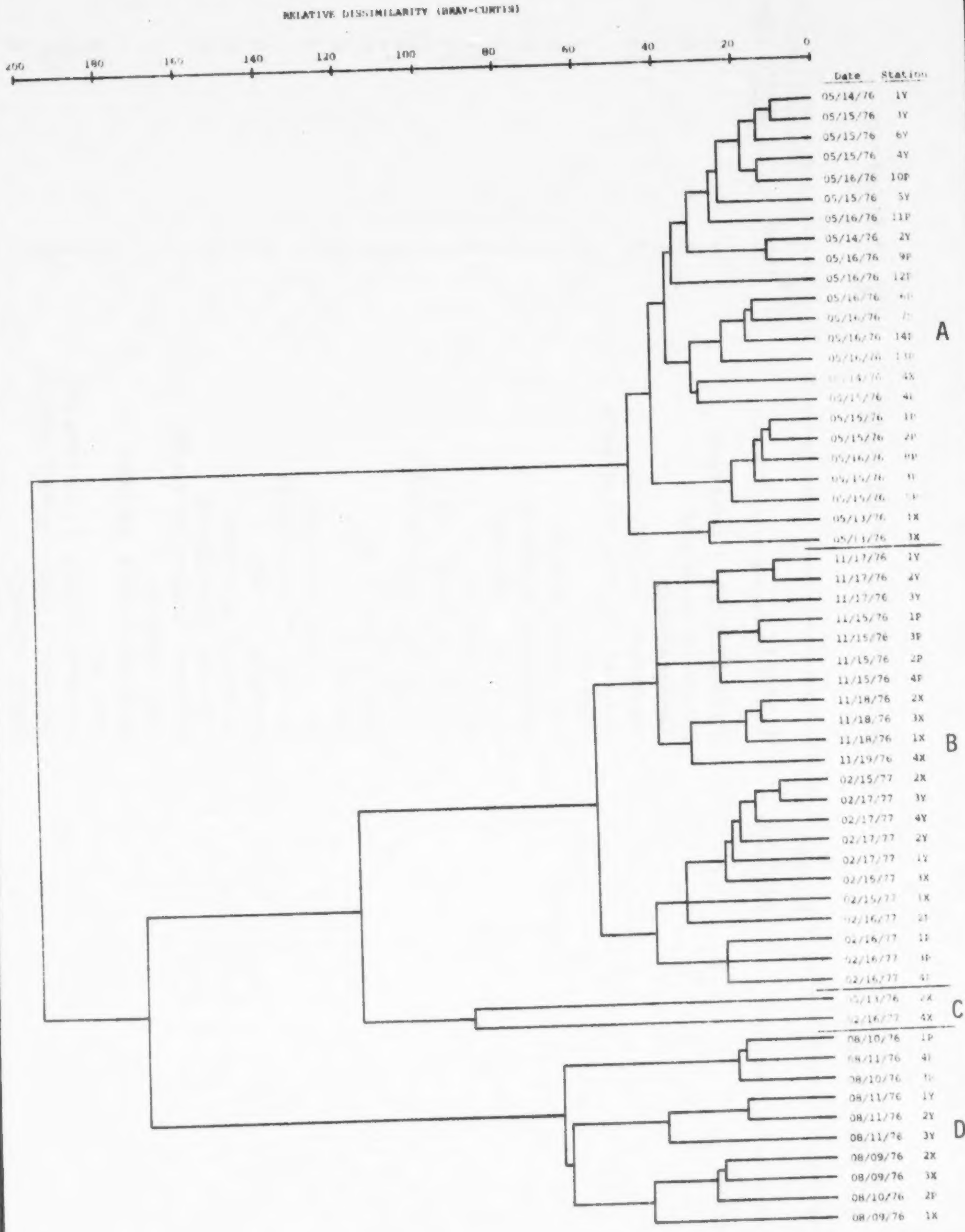


Fig. 1. Normal cluster analysis dendogram for trawl collections made during the 1976-1977 Buccaneer Oil Field Study.

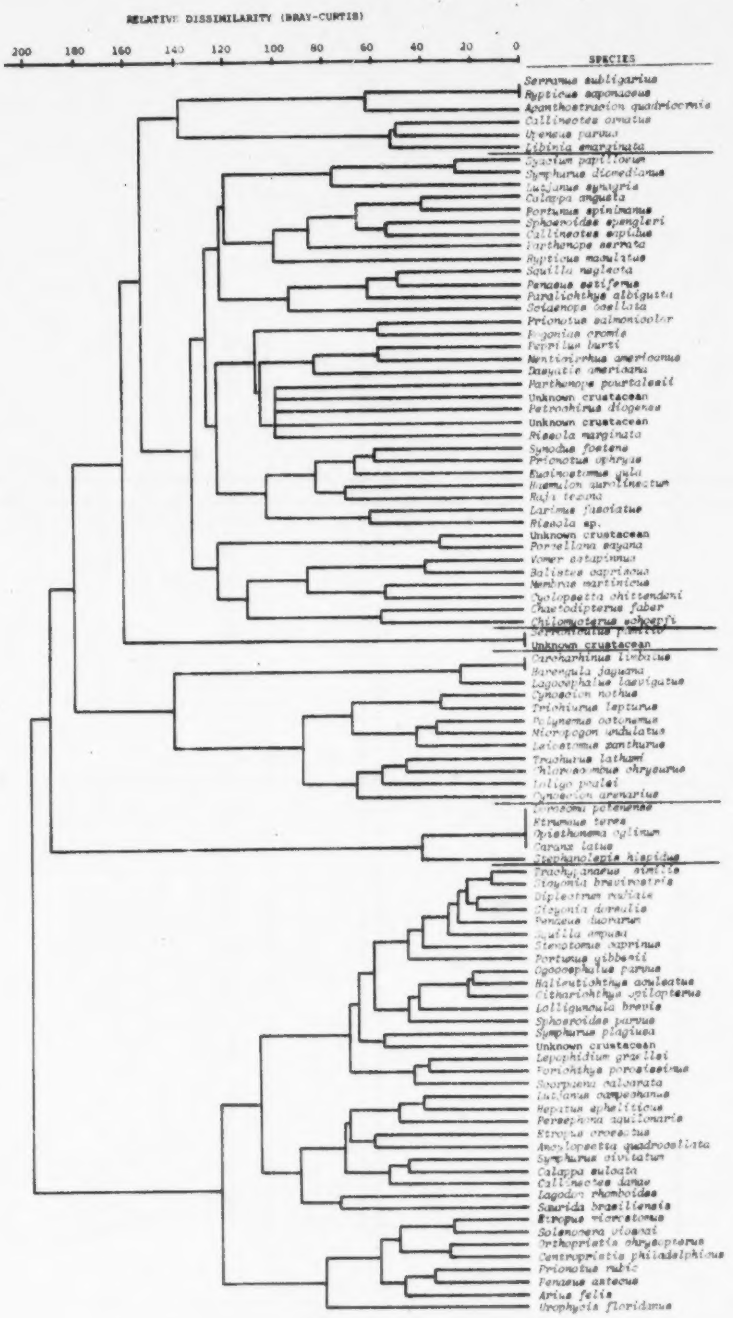
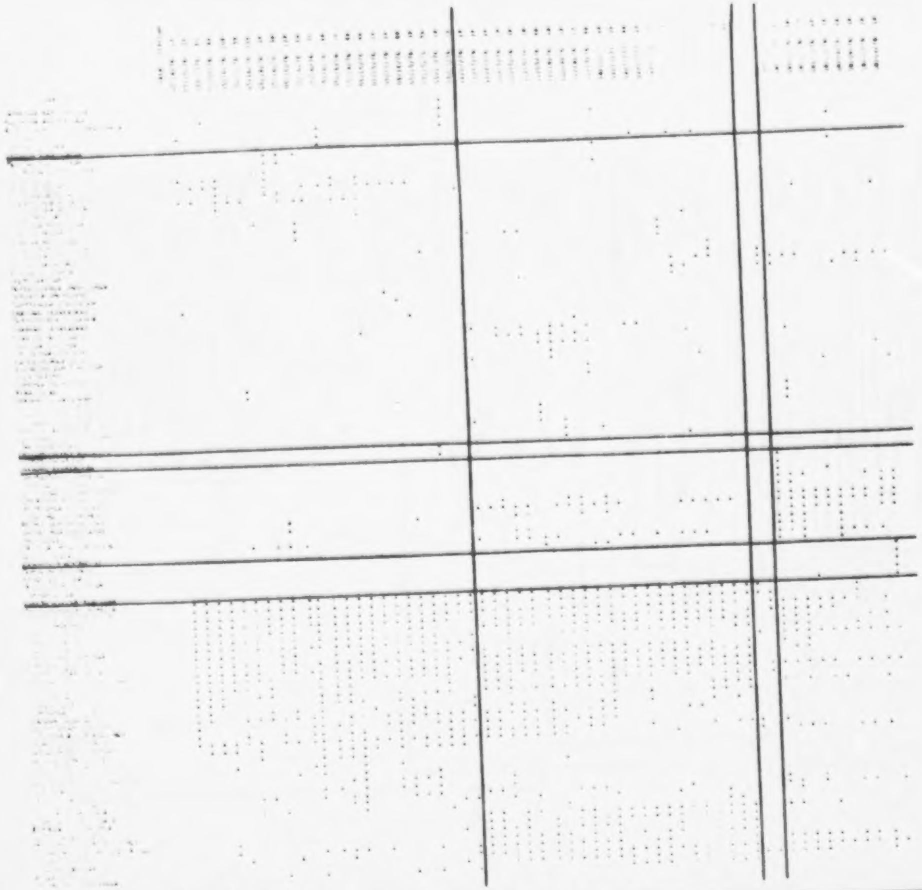


Fig. 2. Inverse cluster analysis dendogram for trawl collections made during the 1976-77 Buccaneer Oil Field Study.



*Indicates presence of taxa in collection.

Fig. 3. Two-way cluster table for trawl collections made during the 1976-77 Buccaneer Oil Field Study.

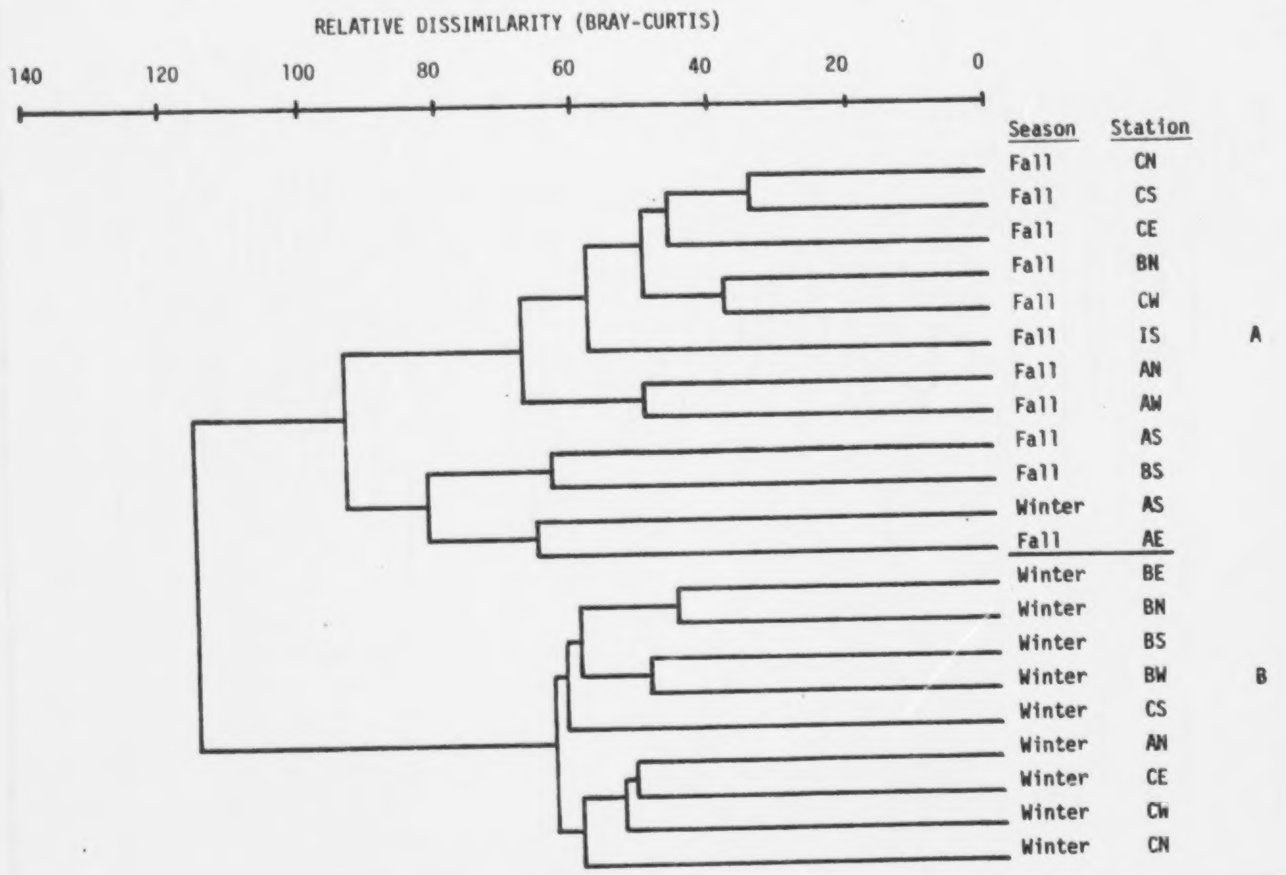


Fig 4. Normal cluster analysis dendogram for trawl collections made during the 1977-78 Buccaneer Oil Field Study.

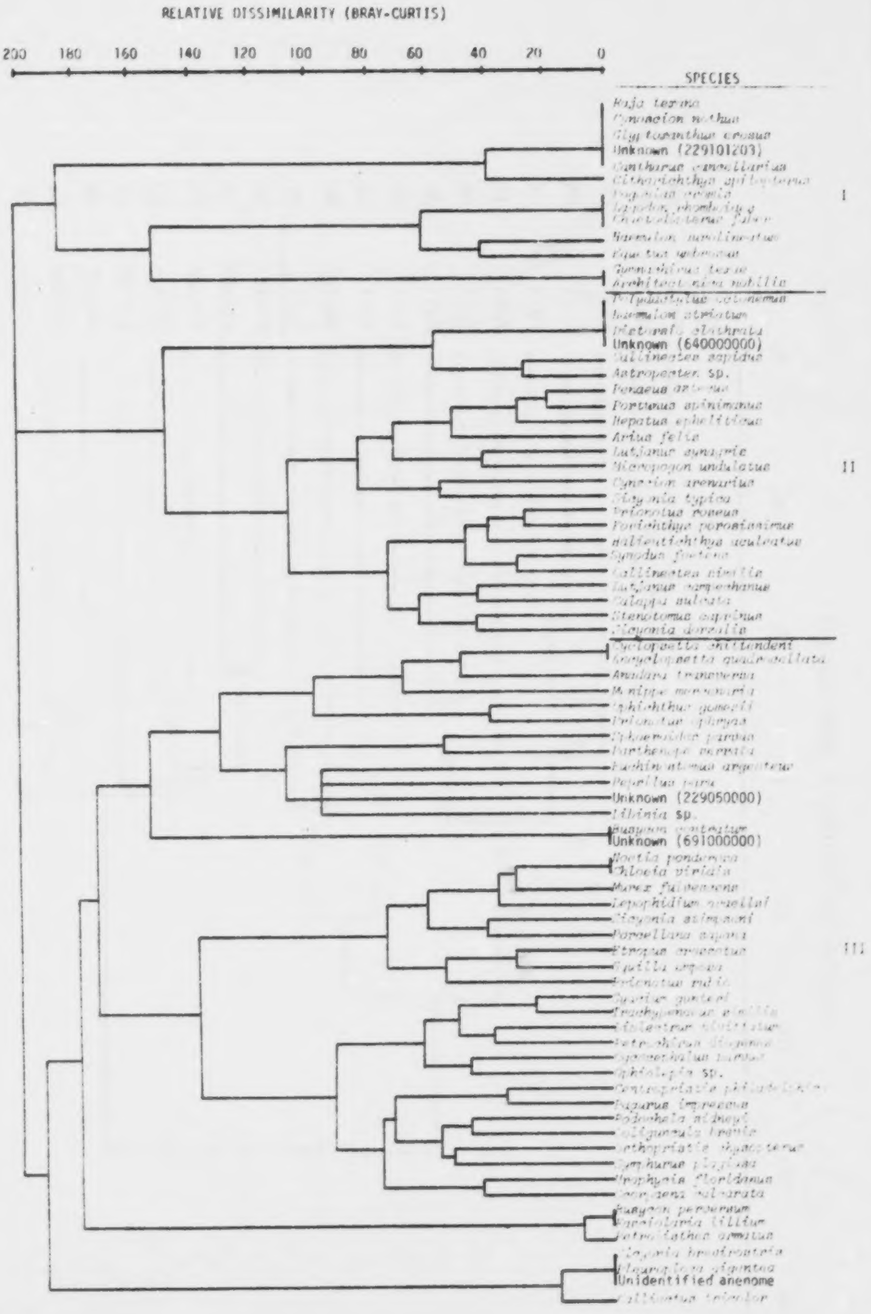


Fig. 5. Inverse cluster analysis dendogram for trawl collections made during the 1977-78 Buccaneer Oil Field Study.

Station	CN	CS	CE	BW	CW	IS	AN	AW	AS	BS	AS	AE	BE	BN	BS	BW	CS	AN	CE	CW	CN
Season	Fall	Fall	Fall	Fall	Fall	Fall	Fall	Fall	Fall	Fall	Winter	Fall	Winter	Winter	Winter	Winter	Winter	Winter	Winter	Winter	Winter
SPECIES																					
Raja texana								*													
Cynoscion nothus								*													
Glyptoxanthus erosus								*													
Unknown (229101203)								*													
Cantharus cancellarius								*													
Citharichthys spilopterus			*					*													
Pogonias cromis			*																		
Lagodon rhomboides			*																		
Chaetodipterus faber			*																		
Haemulon aurolineatum			*				*		*												
Equetus umbrosus			*			*	*				*	*									
Gymnachirus texae							*														
Architectonica nobilis							*														
Polydactylus octonemus						*															
Haemulon striatum						*															
Distorsio clathrata						*															
Unknown (640000000)						*															
Callinectes sapidus				*		*															
Astropecten sp.				*		*					*										
Penaeus aztecus	*	*	*	*	*	*	*	*	*					*	*					*	*
Portunus spinimanus	*	*	*	*	*	*		*										*		*	
Hepatus ephelititcus	*	*	*	*	*	*	*	*													
Arius felis	*	*	*	*	*		*	*	*	*		*									
Lutjanus synagris			*		*	*		*													
Micropogon undulatus						*	*	*													
Cynscion arenarius					*	*						*									
Sicyonia typica	*				*	*				*							*				
Prionotus roseus	*	*				*	*														
Porichthys porosissimus	*	*	*			*															
Halieutichythys aculeatus	*	*		*	*	*	*				*										
Synodus foetens	*	*																			
Callinectes similis	*	*	*	*																	
Lutjanus campechanus		*	*	*	*	*	*		*	*	*	*			*						
Calappa sulcata		*				*				*											
Stenotomus caprinus		*		*		*												*			
Sicyonia dorsalis	*	*	*			*								*				*	*	*	
Cyclopsetta chittendeni				*																	
Ancylopsetta quadrocellata				*																	
Anadara transversa				*																	*
Menippe mercenaria				*				*				*									
Ophichthus gomesii																		*			
Prionotus ophryas				*														*			
Sphoeroides parvus										*											
Parthenope serrata								*		*											*
Euchinostomus argenteus	*								*												
Peprilus paru														*							
Unknown (229050000)											*										
Libinia sp.																*					
Busycon contrarium																	*				
Unknown (691000000)																	*				
Noetia ponderosa																				*	
Chloeia viridis																				*	
Murex fulvescens														*						*	
Lepophidium graellsi																		*		*	
Sicyonia stimpsoni																*				*	*
Porcellana sayana				*																*	*
Etropus crossotus			*											*		*				*	
Squilla empusa														*		*	*			*	
Prionotus rubio													*	*				*		*	
Syacium gunteri	*	*	*	*	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*
Trachypenaeus similis	*	*	*	*	*	*	*		*				*	*	*	*	*	*	*	*	*
Diplectrum bivittatum	*		*	*				*		*			*				*	*	*		
Petrochirus diogenes	*		*	*	*		*	*				*	*	*				*	*	*	*
Ogcocephalus parvus				*	*	*	*				*	*	*				*		*	*	
Ophiolepis sp.	*			*	*												*		*	*	
Centropristis philadelphica		*	*				*											*	*		*
Pagurus impressus			*				*					*						*		*	*
Podochela sidneyi											*					*	*		*		*
Loliguncula brevis											*					*		*	*	*	
Orthopristis chrysopterus			*				*		*		*	*			*		*			*	*
Symphurus plagiusa					*	*					*							*		*	*
Urophycis floridanus														*	*	*		*	*		*
Scorpaena calcarata					*										*			*	*		
Busycon perversum																			*		
Fasciolaria lillium																			*		
Petrolisthes armatus																		*	*		
Sicyonia brevirostris																					*
Pleuroploca gigantea																					*
Unidentified anenome																					*
Calliactus tricolor																		*			*

*Indicates presence of taxa in collection.

Fig. 6. Two-way cluster table for trawl collections made during the 1977-78 Buccaneer Oil Field Study.

Work Unit 2.3.6 Determine the Effects of Discharges on Seasonal Abundance, Distribution, and Composition of Ichthyoplankton in the Oil Field

NMFS/SEFC Panama City Laboratory

J. H. Finucane
L. A. Collins
L. E. Barger

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ABSTRACT

During this study of the Buccaneer Oil Field off Galveston, Texas plankton samples were collected only during July and October 1977 and February 1978 and 39 families, 50 genera and 40 species of pelagic fish larvae were identified. The engraulids, sciaenids, and bothids were the three most abundant taxon. Seasonal sampling showed that the highest larval abundance (59%) and egg abundance (66%) occurred during July. The lowest larval numbers (4%) and the lowest egg numbers (6%) were present during February.

Species diversity was the highest around the production platforms in July and October while during February the greatest species diversity occurred around the satellite structures. When the larval abundance from all three cruises is compared the satellite stations had the highest numbers of larvae followed by the platform stations and then the outside control stations. The species composition of the bongo and neuston catches were often different. Some fish such as the scombrids and exocoetids were only caught in neuston tows while carangids and microdesmids were caught only in bongo tows. Total egg abundance was higher during July at the platforms and during October and February it was highest at the satellite stations. When EPA field stations were compared with BLM stations of equal depths on a seasonal basis, egg and larval numbers were similar.

Based on egg abundance of known taxon the Buccaneer Oil Field is a spawning ground for anguilliformes, collionymids, clupeids, engraulids, sciaenids, scombrids, and soleids. Spawning times and intensity varied on a seasonal basis. These data suggest that the brine discharge and other possible contaminants from the platforms do not appear to affect the ichthyoplankton in the oil field.

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INTRODUCTION

This report presents the results of the continuation of our ichthyoplankton study of the Buccaneer Oil Field in the northwestern Gulf of Mexico. During the first year of this baseline survey from May 1976 to February 1977, quarterly plankton samples were obtained from a series of 8 stations (4 field and 4 control) in an area about 52 km offshore from Galveston, Texas (U.S. Department of Commerce 1976). The present sampling was concentrated around the platforms (A and B) and adjacent satellite structures (Figure 1) in water depths averaging 17 meters and extended from July 1977 to February 1978. The Buccaneer field has been producing oil and gas for about 15 years and is isolated from any other oil field in the area.

The main purpose of this study was to documant the possible effects of brine discharge and other contaminants on fish eggs and larvae from the production platforms. Other objectives were to determine the seasonal abundance, occurrence, distribution and species composition of ichthyoplankton in the oil field and adjacent control areas. By examination of fish eggs and measuring the size of fish larvae, times and places of spawning were determined for selected taxa.

A series of 6 stations was occupied on a seasonal basis during July and October 1977 and February 1978 (Figure 1). Two stations (I and VI) were used as controls for the area outside the oil field and were the same stations that were sampled during our first study. The field stations (II, III, IV, and V) included the two major production platforms (II and IV) and the two adjacent satellite structures (III and V). The later two also served as control stations within the field. In an attempt to document the possible effects of contaminants from the platforms, plankton tows were made around each side of the platforms (A, B, C, and D). A similar series of tows was made around each satellite (Figure 1). The exact station locations and sampling depths are given in Table 1. Additional ichthyoplankton data from the other stations such as displacement volume, mesh size of net, time of collection, amount of filtered water and numbers of eggs and larvae are shown in Tables 2-5.

The literature on ichthyoplankton in the Gulf of Mexico is still rather limited, although much has been reported on the juvenile and adult marine fishes of Texas. The most systematic coverage of fish eggs and larvae off the Texas outer continental shelf was given in our Bureau of Land Management (BLM) final report for 1976 (U.S. Department of Commerce, 1977). The baseline study recorded 71 families, 108 genera and 71 identified species of pelagic

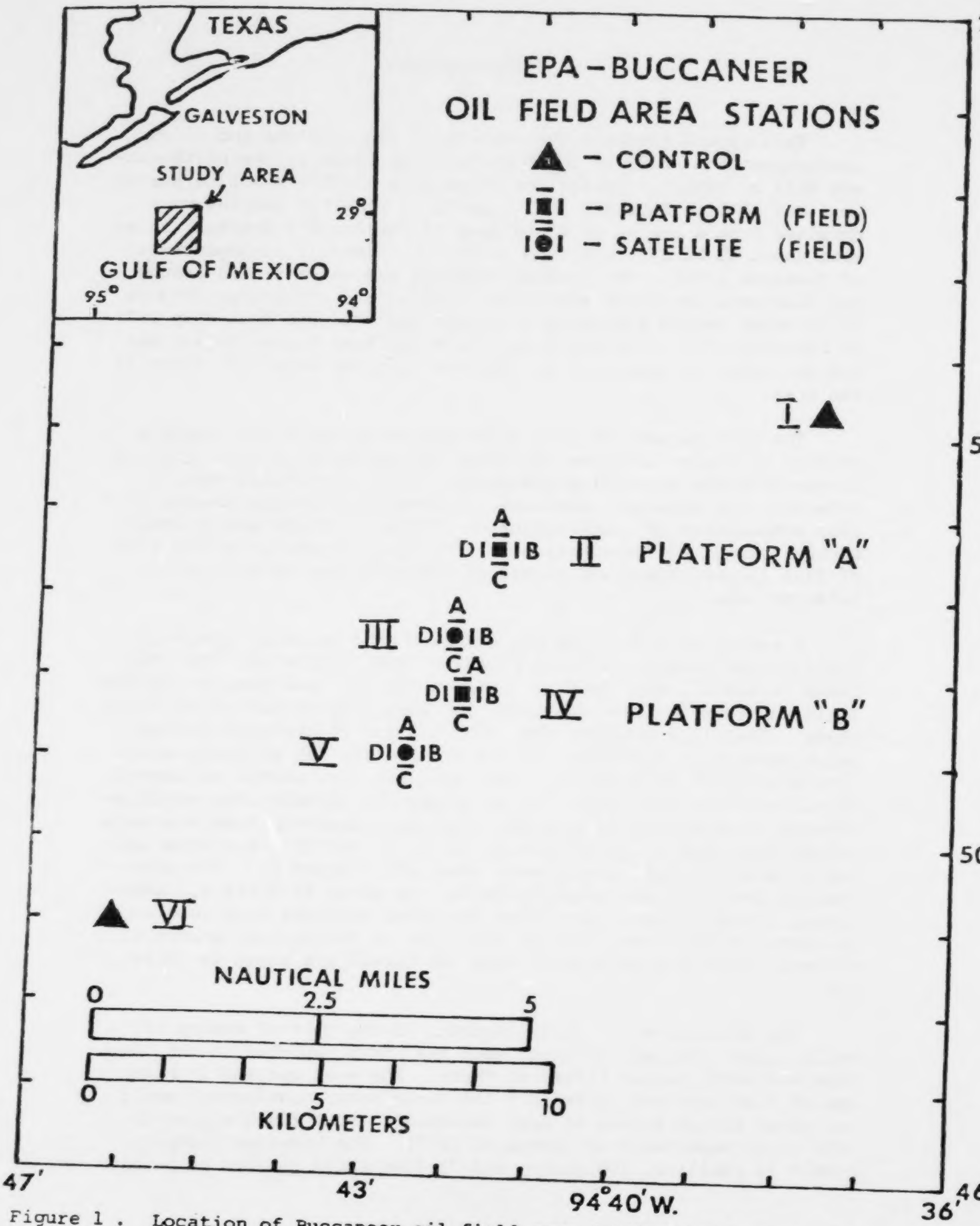
TEXAS
GALVESTON
STUDY AREA
29°
GULF OF MEXICO
95°
94°
EPA-BUCCANEER
OIL FIELD AREA STATIONS
▲ - CONTROL
- PLATFORM (FIELD)
- SATELLITE (FIELD)
29°
N.
I
55'
A
D
B
C
II PLATFORM "A"
III
IV PLATFORM "B"
V
VI
50'
NAUTICAL MILES
0
2.5
5
KILOMETERS
10
47'
43'
94°40' W.
36'
46'

Figure 1 . Location of Buccaneer oil field area ichthyoplankton stations for 1977-1978.

fish larvae and covered almost the entire south Texas coast seaward to a depth of 182 meters. For comparison with the northwestern Gulf of Mexico larval catch, the report of Fahay (1975) provided an excellent list of larval and juvenile fishes comprising 51 families and 107 species that were captured with surface-towed meter nets in the South Atlantic Bight from New River, North Carolina to Palm Beach, Florida on a quarterly basis. In addition to this study, Powles and Stender (1976) gave detailed observations on composition, seasonality and distribution of ichthyoplankton for 1973 also in the South Atlantic Bight. They used standard MARMAP techniques which included both bongo and neuston net samples. Early studies by Gunter (1945, 1950, and 1959) established the species diversity and richness of the fish fauna off the south Texas coast. Hoese (1958) compiled a checklist of 424 species of marine fishes caught in Texas waters and Parker (1965) provided a checklist of the fishes of Galveston Bay, Texas. More recent reference material on the fishes of Texas and the northern gulf was given by Galloway et al. (1972) and Walls (1975). The spawning times of some marine fishes in the Port Aransas, Texas area were listed by Hoese (1965), and Arnold et al. (1960) recorded the larval and juvenile fishes caught in Galveston Lagoon. The papers by Briggs (1958) and Powell et al. (1972) were helpful in determining the known ranges of most fish species in the Gulf.

How crude and refined oils and other toxicants such as brine water affect ichthyoplankton is relatively unknown. Useful references that cover some characteristics of these toxicants and their relationships to estuarine crustaceans, fishes and other animals are given by Anderson et al. (1974a and 1974b), and Moore et al. (1973). A report on an estuarine pollution control and assessment conference is also given by the U.S. Environmental Protection Agency (1975).

Most of the fish larvae during this study were identified from specimens in our own reference collection compiled from six years of ichthyoplankton studies in the Gulf of Mexico. Since the early life history of many marine fishes in the Gulf of Mexico is still unknown, some larval identification was based on available references of the same or related species from other areas. The meristic characteristics of some marine fishes of the Western North Atlantic by Miller and Jorgenson (1973) was particularly useful especially to species level. Other papers covering the early life histories of certain species were helpful. They included Aprieto (1973) on the early development of some carangid fishes, Anderson (1967) on a field guide to the snappers, Kendall (1972) on the black sea bass, and Laroche (1977) on the larval and early juvenile stages of the vermilion snapper. Kendall (1977) also gives the relationship of some serranid fishes based on the morphology of these larvae. Additional references that were used to identify larvae were Leak (1977) on the distribution and abundance of carangidae larvae in the Eastern Gulf of Mexico, Jannke (1971) on the sciaenids of the Florida Everglades, Houde and Fore (1973) on the eggs and larvae of the clupeid fishes in the Gulf of Mexico, Wollam (1970) on Spanish and King mackerels, Mansueti and Hardy (1967) on the fishes of the Chesapeake Bay area, Fourmanoir (1973) on the lutjanid, Symphysanodon sp., and Scotton et al. (1973) on the fish larvae of Delaware Bay.

Various groups such as the sciaenids, serranids and lutjanids were sent to specialists to verify our identifications (see acknowledgments). Most larvae and some eggs were classified to at least family level. Many of the eggs and many of the larvae, especially the anchovy and herring types, were often too mutilated or small to positively identify them.

The classification of most larval fishes followed that given by Bailey et al. (1970). For archival of larval data the bionumeric code developed by Bullis et al. (1972) was used. All ichthyoplankton data have been sent to the Environmental Data Service (EDS) and all fish eggs and larvae are being archived at the Panama City Laboratory.

METHODS AND MATERIAL

Ichthyoplankton collections were made with bongo and neuston net samplers at each station using standard MARMAP sampling gear and techniques (Jossi et al. 1975). The paired bongo samplers have a mouth opening of 61 cm and mesh sizes of 0.333 mm and 0.505 mm (Posgay et al. 1968). A General Oceanics digital flowmeter was placed in the mouth of each bongo net to determine the volume of filtered water during each tow. All flowmeters were calibrated prior to each cruise. Neuston tows were made on the surface with the net partially submerged for a duration of 10 minutes at each station. All neuston tows around the oil field structures were made in a circular pattern about 90 meters from the two platforms and satellites. Sampling effort at these stations consisted of four complete surface tows. The frame of the neuston net had a mouth opening of 0.5 x 1.0 m and mesh size was 0.505 mm. No flowmeter was attached to this net and the neuston plankton samples were only used on a qualitative basis. Neuston tows are an important supplement to the bongo tows, since they often collect late stage larvae and juveniles that are useful in the dynamic method of larval identification. Net tows were made during both the day and night. For the first two cruises, about equal day and night samples were collected. Stations were sampled at whatever time they were reached by the ship. The sampling sequence of stations varied between cruises.

Double oblique net tows were made on all cruises with the bongo gear. All bongo tows were made about 30 meters from the sides of the two platforms and satellite structures so that four complete plankton tows were taken at each structure. The tows were designed to sample the depth strata equally from the surface to near the bottom. Each tow was made with the release of wire at 50 m per min. until the desired depth was reached; wire retrieval was at 20 m per min. A constant monitoring of the wire angle during each bongo tow was done with an inclinometer or a ball-and-tube, pendulum-type angle indicator. In this way ship speed and direction could be changed when necessary to maintain as close to a 45° wire angle as possible. A stopwatch was also used to precisely time each tow. Nets were towed from the stern of each vessel except during Cruise 3 when they were towed from the side of the vessel.

Plankton nets were washed down with seawater before the cod-ends were removed at the end of a tow. The plankton was transferred immediately to jars containing 7% buffered formalin in seawater. In the laboratory, displacement volumes (Table 2) were determined by means of a Yentsch plankton volume gauge after first removing large ctenophores, sargassum, and detrital material (Yentsch and Hebard, 1957). Ichthyoplankton was sorted to the lowest possible taxon from the entire sample; no aliquots were taken. Fish larvae were measured to the nearest 0.1 mm (standard length) or the nearest 1 mm when over 10 mm in size.

Water temperature and salinities were taken during each cruise. Temperatures were measured with expendable, temperature-sensing bathythermographs (XBT) during the first cruise. Surface bucket temperatures were also taken with thermometers graduated to 0.1°C. Salinity samples of surface and bottom waters were taken with Nansen bottle casts; salinities were determined by the Goldberg Refractometer method.

RESULTS

Abundance and species composition.

During this study, 15,711 fish larvae and 13,873 eggs were collected from the three seasonal cruises in the Buccaneer Oil Field. All larval taxa are given for each cruise in Tables 6-8 in descending order of abundance. Taxa representing 39 families, 59 genera and 40 species were identified (Table 9). Species abundance for dominant families is also shown by gear type and cruise (Tables 10-12) and for combined cruises in Table 13. These data show that the engraulids represented 46.9% of the total catch for the first cruise and together with the bothids and clupeids accounted for 72% of all larvae. During the second cruise in October the sciaenids were the dominant larvae representing 50.9% of the total catch and together with the engraulids and gobies accounted for 91.8% of all larvae. During the third cruise the dominant larvae were the clupeids which represented 61.3% of the total catch and together with the sparids and stromateids accounted for 76.5% of all larvae. When the catch of all three cruises are examined the engraulids, sciaenids and bothids were the three most abundant taxa in descending order of abundance.

Species diversity for all larval fishes taken in bongo samples for all stations from July 1977 fo February 1978 is shown in Table 14. These data indicate that during July and October the greatest species diversity occurred in the samples collected around the two production platforms, while during February the greatest species diversity occurred around the two satellite structures. When the catch from all three cruises is compared in descending order of abundance the satellite stations were the highest, the platform stations the second highest, and the outside control stations the lowest.

Larval composition, size and abundance varied between the platforms and satellite structures for all three cruises (Tables 15 and 16). For example the croaker, Micropogon undulatus, was more abundant at the satellite stations as compared to the platforms. The mean size (4.9 mm) of the croaker was larger at the platforms as compared to the satellite stations (2.9 mm). In contrast the sea bass, Diplectrum sp., was more abundant at the platform stations as compared to the satellite structures, and their mean size (4.5 mm) was larger at the satellites as compared to the platform stations (3.4 mm). The species compostiion was similar between the structures, although the general abundance of all fish was greater at the platform stations. When the catches of larvae were combined for both structures, the smallest larvae were found in the serranid, carangid, and sciaenid families. The largest larvae occurred in the engraulid, clupeid and bothid families.

The species composition and relative abundance of the most dominant larvae in the bongo and neuston catches were compared for all three cruises (Table 18 and 19). The catches of engraulids and sciaenids were of about equal magnitude between the two gear types, but the clupeids, bothids and gobies were caught in greater numbers in the neuston tows. Some fish such as the scombrids and exocoetids were only caught in neuston tows, while carangids and microdesmids were caught only in bongo tows. These data indicate that larval mackerels, tunas, and flying fishes prefer survace waters, whereas larval jacks and wormfishes prefer subsurface waters.

Larval and juvenile fishes of especial recreational and commercial value that were in the neuston tows are shown in Table 20. These fish include the sailfish, Istiophorus platypterus; the cobia, Rachycentron canadum; the little tunny, Euthynnus alletteratus; the king mackerel, Scomberomorus cavalla; and the Spanish mackerel, Scomberomorus maculatus.

To determine if any differences existed between larval and egg numbers collected between the platforms and satellite structures, their percentage of total catch and no./1,000 m^3 were calculated (Tables 21 and 22) for the three sampling cruises from July 1977 to February 1978. During July, the highest percentage (61.5%) of fish larvae and no./1,000 m^3 (4.813) occurred at one of the platform stations (IV) and one satellite station (V). A similar abundance pattern was noted for October when the greatest numbers of larvae were collected at the platform station (II) and the adjacent satellite Station (III). During February larvae were more abundant at the platform station (IV) and the satellite station (III). When the total numbers of larvae are compared for all cruises, the greatest abundance of larvae occurred at the satellite or control stations and the least at the platform stations (Table 21). When fish egg abundance was compared, a similar pattern was noted. For example, more eggs were caught during July at the platform station (IV) and the adjacent satellite station (V). During October and February larger numbers of eggs occurred at the platform station (IV) and the satellite station (III). Unlike the larvae, total egg abundance was only higher for July at the platforms, while at the satellites egg abundance was only higher during October and February (Table 22).

A comparison of egg and larval abundance from bongo net tows was also made between similar stations in the oil field during 1976-77 and the platforms during 1977-78 (Table 23). Numbers of eggs and larvae were expressed as the no./1,000 m^3 and no. under 10 m^2. A similar unit of effort was used for both comparisons. Data for the eggs and larvae only from Side D (the brine discharge side) were used for 1977-78. These data show that during the summer sampling, Station III-D had fewer eggs and larvae than the 1976-77 Station B, while platform Station IV-D of the 1977-78 sampling series was higher than Station G of the 1976-77 study. During the fall, Station B was the highest in egg abundance and Station III-D was the highest in larval abundance; Station G was also higher in egg abundance and lower in larval abundance when compared with the platform Station IV-D. The winter egg abundance was higher at Station B as compared to Station III-D, while Station B was lower than Station III-D in larval numbers. Both eggs and larvae were higher at Station III-D when compared to Station G. A similar comparison was made between the two outside the oil field control stations which were the same stations occupied during both studies (Table 24). These control stations are useful in following general larval and egg abundance between the two studies. In general, they reflect areas that should be relatively free of any contamination from the oil field. The egg and larval numbers from these stations show that the deeper offshore stations (H and VI) near Stations IV and V of the oil field had consistently higher abundance of eggs and larvae throughout the year with the exception of the fall sampling period.

Even though sampling times varied, a comparison of egg and larval abundance between EPA oil field stations and BLM stations of equal depths was made from May 1977 to October 1977 (Table 25). These data show that on a seasonal basis egg and larval numbers were usually similar between the oil field and the BLM stations. The latter stations were greater than 100 km southwest of the Buccaneer Oil Field in an area relatively free of any oil field influence.

A direct comparison of egg and larval abundance was also made for each cruise and for all three cruises between Platforms "A" and "B" (II and IV) and their adjacent control stations (III and V). All symbols shown in Figures 2 to 9 are given as the numbers of eggs or larvae under 10 m^2 of sea surface and represent separate plankton tows taken at each side (A, B, C, and D) of these structures. Side D of each platform is the side where the brine pipe is located and where any direct effect of this discharge on ichthyoplankton could be expected. During each of these cruises and for all combined cruises, no differences were noted between egg abundance at Side D when compared to Sides A, B, and C. During Cruises 1 to 3, egg abundance was lower at the platforms as compared to the control stations. This difference in egg numbers was noted mainly at platform "A" (Figure 2 to 5). The general pattern of larval abundance was similar to that of egg abundance and was not different when Side D was compared to the other sides (Figures 6 to 9). When all samples taken around the platforms were compared by cruise only the Platform "A" samples for Cruise 3 were lower than the adjacent control stations (Figure 8). Larval numbers for all three cruises showed no differences between the platforms and control stations (Figure 9).

The abundance of the top ten larval families was also plotted by cruise for the entire sampling period by numbers under 10 m^2 of sea surface (Figures 10 to 39). These families are listed alphabetically as follows: Bothidae, Carangidae, Clupeidae, Engraulidae, Gobiidae, Lutjanidae, Ophidiidae, Sciaenidae, Scombridae, and Serranidae. The bothids were about equally abundant between the platform and control stations during all cruises except during Cruise 2 when no bothids were caught at the brine discharge side of Platform "B" (Figure 11) and during Cruise 3 when no bothids were caught at Platform "A", although they were present at Platform "B" and the other control stations (Figure 12). The abundance pattern for the carangids is shown in Figures 13 to 15. No fish were caught at the brine discharge during Cruises 2 to 3 of Platform "A". Both platforms were lower than the adjacent control stations during Cruise 2 in numbers of fish that were caught. The clupeids were more abundant at both platforms during Cruise

1 and were completely absent during Cruise 2 at each platform. Lower numbers of clupeids occurred at both platforms during Cruise 3 (Figures 16 to 18). The engraulids were lower in abundance during Cruise 1 at Platform "A" and the brine discharge side, although higher numbers occurred at Platform "B" than the control stations (Figure 19). No differences were noted during Cruise 2 between the stations or the brine discharge sides of the stations (Figure 20). The engraulids were virtually absent during Cruise 3 and were caught only at Platform "A" (Figure 21). Goby abundance was higher at both platforms than at the adjacent control stations during Cruise 1 (Figure 22). Their numbers during Cruise 2 were similar between the platforms and control stations, and no fish were caught at the brine discharge side of Platform "B" (Figure 25). No gobies were present at any of the stations during Cruise 3 (Figure 24). The lutjanid abundance for all cruises is shown in Figures 25 to 27. During Cruise 1 no lutjanids were caught at Platform "A" and none were found at any of the stations during Cruises 2 and 3. Greater numbers of ophidiids were collected at the platform stations during Cruises 1 and 2, and none were present during these cruises at the brine discharge side of Platform "A" (Figure 28 and 29). Only the brine discharge side of Platform "B" had any ophidiids when compared to Platform "A" during Cruise 3 (Figure 30). The sciaenids were abundant throughout the oil field and during Cruise 1 were present at all Platform "B" and adjacent control stations and only one Platform "A" and control stations (Figure 31). In contrast, during Cruise 2 they were caught at all platforms and control stations in about equal numbers (Figure 32), and during Cruise 3 they were absent at both platforms (Figure 33). The scombrids were collected only during Cruise 1 and reached their highest abundance at Platform "B". They occured only at one of the Platform "A" stations and were completely absent during Cruises 2 and 3 at all stations (Figures 34 to 36). The serranids were most abundant during cruise 1, and the Platform "B" stations showed higher numbers of larvae as compared to Platform "A" and the control stations (Figure 37). No larvae were collected at the brine side of Platform "A". Serranid larvae were absent from all stations in Cruise 2 and Platform "A" in Cruise 3 (Figures 38 and 39).

To further show larval abundance numbers of larvae under 10 m^2 of sea surface of selected genera and species that are representative of recreationally and commercially important fish were plotted for the platforms and control stations by cruises (Figures 40 to 69). The variability of abundance noted among the larval families between platforms and control stations extended to the genus and species level. In many cases larvae were only collected at Platform "B" or its adjacent control station. For example, during Cruise 1, *Harengula jaguana* and *Cynoscion nothus* were caught at Platform "B" and the adjacent control station but not Platform "A" or its control station (Figures 42 and 44). In contrast larvae of *Syacium* sp. and *Diplectrum* sp. were abundant at all stations (Figure 41). *Diplectrum* sp. were also caught in greater numbers at the platform stations when compared to the control stations (Figure 45). During Cruise 2, significantly more larvae of Anchoa sp. were collected at Platform "A" and its control station (Figure 52). At no time during the three cruises were larvae absent from the brine discharge side from both platforms at the same time. In many cases, larvae of the same species were absent from the brine discharge side at Platform "A" but were captured at the brine discharge side of Platform "B" (Figures 40, 42, 44, 53, and 56).

Seasonal occurrence and distribution

The three sampling cruises gave some seasonal coverage during the summer, fall, and winter (Tables 3 to 5). The highest larval and egg abundance was noted during July when 59% of the larvae and 66% of the eggs were collected. The lowest larval numbers (4%) and the lowest egg numbers (6%) were noted in February. The species diversity was the highest in July and the lowest in February.

During this study when salinity and temperature ranges were compared by taxon, some preferences were noted (Table 26). Larvae of *Brevoortia patronus* occurred only at temperatures ranging from 10.8 - 12.3 C and at salinities from 31.9 - 35.1 ‰. In contrast *Harengula jaguana* were collected only at temperatures ranging from 23.0 - 24.9°C and at salinities from 22.8 - 34.0 ‰.

Larval dominance varied by season (Tables 6 to 8). For example, the engraulids were the dominant family during the summer and fall and were virtually absent from the catch in the winter. The clupeids were the most abundant family during the winter and the third highest in the summer and only the ninth highest in the fall. The sciaenids were the second highest in larval abundance also during the fall and were completely absent in the summer.

Distribution of all larval taxa from the Buccaneer Oil Field and adjacent area by family, genus, and species is given in Table 27. These data show definite larval preferences between stations and sampling areas. Some fish such as *Syacium gunteri*, *Anchoa* sp., *Symphurus* sp. and *Cynoscion* sp. occurred throughout the sampling area. Others such as *Mugil cephalus*, and *Sphyraena* sp. were caught only at the satellite stations, while *Alectis crinitus*, and *Leiostomus xanthurus* were collected only at the platform stations.

Spawning

Egg abundances of known taxa indicate that the Buccaneer Oil Field is a spawning ground for anguilliformes, callionymids, clupeids, engraulids, sciaenids, scombrids and soleids (Table 28). These data show that spawning times and intensity vary on a seasonal basis. For example, eggs of the clupeids were collected only during October and February, eggs of the engraulids only during July and February, and eggs of the sciaenids only during July in the oil field. Based on the number of eggs per 1,000 m^3 the engraulids and sciaenids were more abundant around the platforms, while the clupeids were more abundant around the adjacent satellite structures. Some of the highest egg counts were taken from the brine discharge side of the platforms during July. Peak spawning for most fish, shown in Table 28, also occurred in July.

The size range of larvae and their relative abundance give another indication of spawning time, place and intensity (Tables 15 to 17). Many larvae, such as the engraulids, sciaenids, bothids, and clupeids, were present throughout the entire sampling period (Table 17). Spawning for some fish was often restricted. For example, Bothus ocellatus were collected only during July, while Brevoortia sp. were taken only during February. Spawning intensity also varied. The highest numbers per 1,000 m^3 of Micropogon undulatus occurred during October, and the highest numbers of Syacium sp. and Lutjanus campechanus occurred in July. During February the clupeids were the dominant spawners. In some cases more larvae were caught around the platforms than around the satellite structures. For example, the catch of Cynoscion sp. was greater around the platforms in October (Table 15). The reverse pattern was also noted for some species. For example, more Anchoa sp. were taken around the satellite structures in October and more clupeids in February.

DISCUSSION

Much was learned during these studies on the relative abundance, distribution and seasonal occurrence of the ichthyoplankton in the Buccaneer Oil Field, but much still remains to be done to precisely document the possible effect of the oil and gas structures and their associated discharges on the biota. We feel that laboratory experiments are needed where animals can be subjected to rigidly controlled conditions, so that many of the variables that affect fish eggs and larvae can be identified, and so that the effects can be observed and described. It would be desirable to conduct similar field studies at a new site so that before, during, and after data can be obtained. It is also important to monitor the Buccaneer Oil Field on a long term basis to enlarge the data base.

CONCLUSIONS

During the two years of this ichthyoplankton study the Buccaneer Oil Field and adjacent coastal waters were found to be highly productive. Species diversity during both years was greater in the field area as compared to the outside control area. Data on larval sizes and egg abundance indicated that the study area is a spawning ground for callionynids, clupeids, engraulids, scombrids, sciaenids, and soleids. These data also suggest that the oil and gas platforms serve as attractants to fish for utilizing this area for spawning. No definite effect of the brine discharge from the platforms or other possible substances from these structures was noted.

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APPENDIX

Table 1 . Station depths and locations in the 1977-78 EPA-Buccaneer oil field ichthyoplankton study.

Station	Study Area	Depth (m)	Latitude (N)			Longitude (W)		
			°	'	"	°	'	"
I	Control*	17	28	55	15	94	37	36
II-A	Platform "A"	17	28	53	29	94	41	27
II-B	Platform "A"	17	28	53	28	94	41	24
II-C	Platform "A"	17	28	53	27	94	41	27
II-D	Platform "A"	17	28	53	28	94	41	30
III-A	Satellite "N"	17	28	52	34	94	41	54
III-B	Satellite "N"	17	28	52	33	94	41	51
III-C	Satellite "N"	17	28	52	32	94	41	54
III-D	Satellite "N"	17	28	52	33	94	41	57
IV-A	Platform "B"	17	28	52	04	94	41	51
IV-B	Platform "B"	17	28	52	03	94	41	48
IV-C	Platform "B"	17	28	52	02	94	41	51
IV-D	Platform "B"	17	28	52	03	94	41	54
V-A	Satellite "S"	17	28	51	07	94	42	27
V-B	Satellite "S"	17	28	51	06	94	42	24
V-C	Satellite "S"	17	28	51	05	94	42	27
V-D	Satellite "S"	17	28	51	06	94	42	30
VI	Control**	17	28	49	00	94	46	05

*1976-77 Station "E"
**1976-77 Station "H"

Table 2 . Displacement volumes in milliliters of plankton from all EPA stations by gear type for July 1977 to February 1978.

	July			October			February		
Station	Bongo	Bongo	Neuston	Bongo	Bongo	Neuston	Bongo	Bongo	Neuston
	.505 mm	.333 mm	.505 mm	.505 mm	.333 mm	.505 mm	.505 mm	.333 mm	.505 mm
I	9.6	19.3	23.9	5.3	2.2	13.3	0.4	5.7	L
II-A	5.3	9.6	14.1	2.1	6.7	19.7	0.4	0.4	8.8
II-B	3.0	4.0	14.7	3.6	5.5	11.7	0.6	0.4	20.9
II-C	4.3	6.0	22.9	5.3	3.7	16.3	0.4	0.4	7.1
II-D	3.4*	3.8*	26.0*	3.2*	4.3*	15.2*	0.4*	0.6*	4.5*
III-A	4.3	8.4	2.4	8.4	10.2	14.1	1.0	0.4	9.0
III-B	6.6	9.5	2.1	3.5	3.7	11.0	1.4	3.2	3.1
III-C	5.5	5.2	2.7	4.3	1.0	12.9	1.2	4.0	3.7
III-D	6.9	7.2	9.4	1.6	3.2	20.9	1.7	4.4	3.8
IV-A	2.1	7.9	13.7	2.1	3.8	7.7	0.4	1.0	9.2
IV-B	9.7	12.6	56.7	3.4	7.7	16.3	1.3	3.8	2.9
IV-C	10.2	12.5	48.3	2.2	4.0	13.5	1.7	4.4	10.9
IV-D	7.4*	13.5*	39.8*	0.4*	2.0*	7.2*	1.0*	4.0*	3.1*
V-A	4.0	4.0	28.5	4.1	1.6	11.2	1.9	4.3	8.5
V-B	3.5	5.1	28.7	0.8	2.3	8.5	2.5	4.4	2.0
V-C	6.7	8.4	29.4	3.1	5.4	9.3	2.1	5.7	10.1
V-D	6.1	6.2	22.6	4.7	4.5	11.5	2.5	13.5	54.7
VI	3.2	4.4	2.3	8.3	6.3	14.8	1.3	18.3	14.2

L Sample lost
* Brine discharge side

Table 3. EPA ichthyoplankton data for first sampling cruise, July 13-14, 1977, by station and time taken from bongo tows.

Station	Mesh size (mm)	Date (1977)	Time (CST)	Water filtered per m^3	Total egg eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
I	.505	7/14	1900	94.0	2	21	59	628
	.333			101.2	65	642	205	2,026
II-A	.505	7/14	1709	24.6	0	0	15	610
	.333			23.1	9	390	41	1,775
II-B	.505	7/14	1637	105.4	0	0	6	57
	.333			111.1	9	81	27	243
II-C	.505	7/14	1654	52.7	0	0	15	285
	.333			53.6	4	75	22	410
II-D*	.505	7/14	1617	29.9	1	33	11	368
	.333			29.8	16	537	9	302
III-A	.505	7/14	1324	106.3	8	75	17	160
	.333			107.9	65	602	27	250
III-B	.505	7/14	1348	45.4	10	220	13	286
	.333			44.8	51	1,138	31	692
III-C	.505	7/14	1403	12.2	17	1,393	19	1,557
	.333			12.1	30	2,479	26	2,149
III-D	.505	7/14	1422	109.9	17	155	21	191
	.333			115.4	66	572	63	546
IV-A	.505	7/13	1950	41.8**	14	335	49	1,172
	.333			43.1**	21	487	162	3,759
IV-B	.505	7/13	2056	42.0**	1	24	176	4,190
	.333			43.4**	64	1,475	271	6,244
IV-C	.505	7/13	2155	42.4**	15	354	223	5,259
	.333			43.8**	119	2,717	302	6,895
IV-D*	.505	7/13	2130	36.2**	529	14,613	172	4,751
	.333			39.3**	735	18,702	243	6,183
V-A	.505	7/13	2359	105.6	3	28	52	492
	.333			109.0	20	275	62	569
V-B	.505	7/13	2335	28.4	2	70	55	1,937
	.333			36.6	48	1,311	97	2,650
V-C	.505	7/13	2310	40.7	14	344	105	2,580
	.333			43.0	932	21,674	126	2,930
V-D	.505	7/14	0027	32.8	8	244	68	2,073
	.333			39.1	60	1,535	73	1,867
VI	.505	7/14	1200	32.1	55	1,713	16	498
	.333			36.8	166	4,511	87	2,364

*Brine discharge side

** Estimated values

Table 4 . EPA ichthyoplankton data for second sampling cruise, October 13-14, 1977, by station and time taken from bongo tows.

Station	Mesh size (mm)	Date (1977)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
I	.505	10/13	1945	30.0	34	1,133	43	1,433
	.333			32.6	29	890	34	1,043
II-A	.505	10/13	2140	19.9	0	0	36	1,809
	.333			21.2	1	47	124	5,849
II-B	.505	10/13	2200	27.4	1	37	83	3,029
	.333			29.6	2	68	84	2,838
II-C	.505	10/13	2230	26.1	13	498	75	2,874
	.333			28.3	5	177	89	3,145
II-D*	.505	10/13	2253	27.8	5	180	93	3,345
	.333			28.3	4	141	66	2,332
III-A	.505	10/13	2357	23.0	52	2,261	455	19,783
	.333			25.1	19	757	152	6,056
III-B	.505	10/14	0019	30.9	8	259	126	4,078
	.333			23.9	11	334	129	3,921
III-C	.505	10/14	0043	29.0	18	621	131	4,517
	.333			30.8	18	584	74	2,403
III-D	.505	10/14	0100	26.4	12	454	82	3,106
	.333			28.8	16	556	92	3,194
IV-A	.505	10/14	1652	33.4	10	299	34	1,018
	.333			35.1	11	313	44	1,254
IV-B	.505	10/14	1555	31.3	9	288	34	1,086
	.333			32.5	3	92	43	1,323
IV-C	.505	10/14	1616	22.2	0	0	43	1,937
	.333			24.0	5	208	69	2,875
IV-D*	.505	10/14	1634	28.3	2	71	29	1,025
	.333			29.8	4	134	50	1,678
V-A	.505	10/14	1346	30.8	11	357	39	1,266
	.333			33.4	6	180	29	868
V-B	.505	10/14	1402	27.2	3	110	11	404
	.333			28.8	6	21	17	590
V-C	.505	10/14	1423	23.1	2	87	12	520
	.333			26.1	6	230	26	996
V-D	.505	10/14	1438	25.9	1	39	15	579
	.333			28.2	4	142	17	603
VI	.505	10/14	1040	32.8	8	244	34	1,037
	.333			35.9	6	167	28	780

*Brine discharge side

Table 5. EPA ichthyoplankton data for third sampling cruise, February 20 and 22, 1978, by station and time taken from bongo tows.

Station	Mesh size (mm)	Date (1978)	Time (CST)	Water filtered per m^3	Total number eggs	Number eggs per 1,000 m^3	Total number larvae	Number larvae per 1,000 m^3
I	.505	2/20	1555	24.9	2	80	0	0
	.333			28.0	2	71	0	0
II-A	.505	2/20	1720	22.9	0	0	1	44
	.333			21.0	0	0	2	95
II-B	.505	2/20	1751	31.8**	0	0	0	0
	.333			34.3	0	0	4	117
II-C	.505	2/20	1842	28.7**	2	70	8	279
	.333			31.0	9	290	12	387
II-D	.505	2/20	1857	74.6**	0	0	1	13
	.333			80.5**	2	25	3	37
III-A	.505	2/22	1130	30.3	4	132	1	33
	.333			36.2	3	83	17	470
III-B	.505	2/22	1145	30.3	4	132	2	66
	.333			33.9	3	88	20	590
III-C	.505	2/22	1209	30.9	6	194	7	227
	.333			33.9	2	59	19	560
III-D	.505	2/22	1227	32.4	2	62	4	123
	.333			35.8	6	168	38	1,062
IV-A	.505	2/20	1949	30.6**	0	0	3	98
	.333			33.0	0	0	6	182
IV-B	.505	2/22	1301	30.5	7	230	4	131
	.333			33.6	2	60	10	298
IV-C	.505	2/22	1321	31.8	6	189	16	503
	.333			32.7	4	122	25	765
IV-D*	.505	2/22	1341	31.1	10	322	11	354
	.333			34.8	5	144	14	402
V-A	.505	2/22	1431	27.3	1	37	5	183
	.333			29.5	0	0	10	339
V-B	.505	2/22	1449	27.1	5	185	8	295
	.333			29.7	4	135	11	370
V-C	.505	2/22	1936	34.2	1	29	3	88
	.333			38.2	7	183	8	209
V-D	.505	2/22	1958	29.2	0	0	8	274
	.333			32.2	1	31	14	435
VI	.505	2/22	1850	24.5	5	204	5	204
	.333			27.8	29	1,043	67	2,410

*Brine discharge side

**Estimated values

Table 6 . Species list for first cruise, July 13-14, 1977, showing fish larvae in descending order of abundance for all gear types.

Family	Genus	Species	No.	Percent of Total catch
ENGRAULIDAE	---	---	4,048	43.7
BOTHIDAE	*Syacium*	sp.	823	8.9
CLUPEIDAE	---	---	616	6.6
GOBIIDAE	---	---	395	4.3
CLUPEIDAE	*Harengula*	*jaguana*	376	4.1
ENGRAULIDAE	*Anchoa*	sp.	292	3.2
EXOCOETIDAE	---	---	282	3.0
BOTHIDAE	---	---	200	2.2
SCIAENIDAE	*Cynoscion*	*nothus*	200	2.2
BOTHIDAE	*Syacium*	*gunteri*	170	1.8
BOTHIDAE	*Bothus*	*ocellatus*	143	1.5
CYNOGLOSSIDAE	*Symphurus*	sp.	99	1.1
MICRODESMIDAE	*Microdesmus*	sp.	98	1.1
SCOMBRIDAE	*Euthynnus*	*alletteratus*	94	1.0
LUTJANIDAE	*Lutjanus*	*campechanus*	93	1.0
SCOMBRIDAE	*Scomberomorus*	*cavalla*	74	0.8
TETRAODONTIDAE	*Sphoeroides*	sp.	72	0.8
LUTJANIDAE	---	---	71	0.8
SERRANIDAE	*Diplectrum*	sp.	65	0.7
SERRANIDAE	*Serraniculus*	*pumilio*	56	0.6
ENGRAULIDAE	*Engraulis*	*eurystole*	48	0.5
OPHIDIIDAE	---	---	47	0.5
SCIAENIDAE	*Menticirrhus*	sp.	47	0.5
CARANGIDAE	---	---	42	0.5
OGCOCEPHALIDAE	---	---	35	0.4
SERRANIDAE	---	---	24	0.3
CLUPEIDAE	*Opisthonema*	*oglinum*	22	0.2
SCIAENIDAE	*Cynoscion*	sp.*	18	0.2
SCOMBRIDAE	---	---	17	0.2
CARANGIDAE	*Chloroscombrus*	*chrysurus*	16	0.2
SCORPAENIDAE	*Scorpaena*	sp.	13	0.1
BLENNIIDAE	---	---	11	0.1
GERREIDAE	*Eucinostomus*	sp.	9	0.1
MULLIDAE	---	---	9	0.1
SCOMBRIDAE	*Scomberomorus*	*maculatus*	9	0.1
BOTHIDAE	*Bothus*	sp.	7	0.1
EXOCOETIDAE	*Prognichthys*	*gibbifrons*	7	0.1
MURAENIDAE	*Gymnothorax*	sp.	7	0.1
OPHICHTHIDAE	*Myrophis*	sp.	7	0.1
RACHYCENTRIDAE	*Rachycentron*	*canadum*	7	0.1
EXOCOETIDAE	*Parexocoetus*	*brachypterus*	6	0.1
GERREIDAE	---	---	6	0.1
CARANGIDAE	*Decapterus*	*punctatus*	4	**
EPHIPPIDAE	*Chaetodipterus*	*faber*	4	**
EXOCOETIDAE	*Hirundichthys*	*affinis*	4	**
GRAMMISTIDAE	*Rypticus*	sp.	4	**
SPHYRAENIDAE	*Sphyraena*	sp.	4	**
BOTHIDAE	*Cyclopsetta*	sp.	3	**

Table 6 . (Continued)

Family	Genus	Species	No.	Percent of Total catch
EXOCOETIDAE	*Cypselurus*	sp.	3	**
LUTJANIDAE	*Etelis*	*oculatus*	3	**
OPHICHTHIDAE	---	---	3	**
SCIAENIDAE	---	---	3	**
SYNODONTIDAE	*Synodus*	*foetens*	3	**
TETRAODONTIDAE	---	---	3	**
BELONIDAE	---	---	2	**
BELONIDAE	*Ablennes*	*hians*	2	**
BLENNIIDAE	*Hypleurochilus*	*geminatus*	2	**
BOTHIDAE	*Caranx*	sp.	2	**
ISTIOPHORIDAE	*Istiophorus*	*platypterus*	2	**
MURAENIDAE	---	---	2	**
SCIAENIDAE	*Larimus*	*fasciatus*	2	**
TRIGLIDAE	*Prionotus*	sp.	2	**
BOTHIDAE	*Cyclopsetta*	*fimbriata*	1	**
BOTHIDAE	*Monolene*	sp.	1	**
CARANGIDAE	*Alectis*	*crinitus*	1	**
PRIACANTHIDAE	---	---	1	**
SCIAENIDAE	*Bairdiella*	*chrysura*	1	**
SYNODONTIDAE	---	---	1	**
SYNODONTIDAE	*Saurida*	sp.	1	**
SYNODONTIDAE	*Synodus*	sp.	1	**
UNKNOWNS	---	---	522	5.6
		Total	9,268	99.7

* - Probably *Cynoscion nothus* (too small to positively identify)

** - Value less than 0.05

Table 7 . Species list for second cruise, October 13-14, 1977, showing fish larvae in descending order of abundance for all gear types.

Family	Genus	Species	No.	Percent of Total catch
ENGRAULIDAE	---	--- *	1,750	30.1
SCIAENIDAE	Cynoscion	sp. **	1,436	24.7
SCIAENIDAE	Micropogon	undulatus	1,409	24.3
ENGRAULIDAE	Anchoa	sp.	449	7.7
GOBIIDAE	---	---	178	3.1
OPHIDIIDAE	Rissola	marginata	105	1.8
SCIAENIDAE	Menticirrhus	sp.	63	1.1
BOTHIDAE	---	---	62	1.1
SCIAENIDAE	---	---	37	0.6
BOTHIDAE	Syacium	sp.	34	0.6
CARANGIDAE	Chloroscombrus	chrysurus	28	0.5
CARANGIDAE	---	---	17	0.3
CLUPEIDAE	---	---	17	0.3
BLENNIIDAE	---	---	15	0.3
OPHIDIIDAE	---	---	14	0.2
SCIAENIDAE	Cynoscion	nothus	11	0.2
BALISTIDAE	Monacanthus	sp.	9	0.2
SCIAENIDAE	Larimus	fasciatus	9	0.2
TETRAODONTIDAE	Sphoeroides	sp.	9	0.2
CYNOGLOSSIDAE	Symphurus	sp.	6	0.1
OPHICHTHIDAE	---	---	5	0.1
TRIGLIDAE	Prionotus	sp.	5	0.1
OPHICHTHIDAE	Myrophis	sp.	4	0.1
BLENNIIDAE	Hypleurochilus	geminatus	3	0.1
BOTHIDAE	Syacium	gunteri	3	0.1
EXOCOETIDAE	Parexocoetus	brachypterus	3	0.1
STROMOTEIDAE	Peprilus	alepidotus	3	0.1
BOTHIDAE	Bothus	sp.	1	***
GERREIDAE	Eucinostomus	sp.	1	***
MYCTOPHIDAE	Diaphus	sp.	1	***
MYCTOPHIDAE	Notoscopelus	resplendens	1	***
SCOMBRIDAE	Scomberomorus	cavalla	1	***
SCOMBRIDAE	Scomberomorus	maculatus	1	***
SERRANIDAE	---	---	1	***
UNKNOWNS	---	---	117	2.0
		Total	5,808	100.3

* - Probably Anchoa sp. (too small to positively identify)

** - Probably Cynoscion nothus (too small to positively identify)

*** - Value less than 0.045

Table 7. (Continued)

Family	Genus	Species	No.	Percent of Total catch
EXOCOETIDAE	Cypselurus	sp.	3	**
LUTJANIDAE	Etelis	oculatus	3	**
OPHICHTHIDAE	---	---	3	**
SCIAENIDAE	---	---	3	**
SYNODONTIDAE	Synodus	foetens	3	**
TETRAODONTIDAE	---	---	3	**
BELONIDAE	---	---	2	**
BELONIDAE	Ablennes	hians	2	**
BLENNIIDAE	Hypleurochilus	geminatus	2	**
BOTHIDAE	Caranx	sp.	2	**
ISTIOPHORIDAE	Istiophorus	platypterus	2	**
MURAENIDAE	---	---	2	**
SCIAENIDAE	Larimus	fasciatus	2	**
TRIGLIDAE	Prionotus	sp.	2	**
BOTHIDAE	Cyclopsetta	fimbriata	1	**
BOTHIDAE	Monolene	sp.	1	**
CARANGIDAE	Alectis	crinitus	1	**
PRIACANTHIDAE	---	---	1	**
SCIAENIDAE	Bairdiella	chrysura	1	**
SYNODONTIDAE	---	---	1	**
SYNODONTIDAE	Saurida	sp.	1	**
SYNODONTIDAE	Synodus	sp.	1	**
UNKNOWNS	---	---	522	5.6
		Total	9,268	99.7

* - Probably Cynoscion nothus (too small to positively identify)
** - Value less than 0.045

Table 8. Species list for third cruise, February 20, and 22, 1978, showing fish larvae in descending order of abundance for all gear types.

Family	Genus	Species	No.	Percent of total catch
CLUPEIDAE	---	---	200	31.9
CLUPEIDAE	*Brevoortia*	sp.	184	29.4
SPARIDAE	*Lagodon*	*rhomboides*	35	5.6
STROMATEIDAE	*Peprilus*	*burti*	32	5.1
POMADASYIDAE	---	---	29	4.6
SPARIDAE	---	---	28	4.5
CARANGIDAE	*Trachurus*	*lathami*	16	2.6
SERRANIDAE	*Centropristis*	sp.	13	2.1
BOTHIDAE	---	---	10	1.6
OPHIDIIDAE	*Rissola*	*marginata*	6	1.0
SCIAENIDAE	---	---	6	1.0
BOTHIDAE	*Paralichthys*	sp.	5	0.8
SYNODONTIDAE	*Saurida*	sp.	4	0.6
TRIGLIDAE	*Prionotus*	sp.	4	0.6
BLENNIIDAE	---	---	2	0.3
BREGMACEROTIDAE	*Bregmaceros*	*atlanticus*	2	0.3
SCIAENIDAE	*Micropogon*	*undulatus*	2	0.3
SERRANIDAE	---	---	2	0.3
SYNODONTIDAE	*Synodus*	sp.	2	0.3
CLUPEIDAE	*Brevoortia*	*patronus*	1	0.2
ENGRAULIDAE	---	---	1	0.2
GADIDAE	*Urophycis*	sp.	1	0.2
MUGILIDAE	*Mugil*	*cephalus*	1	0.2
OPHICHTHIDAE	---	---	1	0.2
SCIAENIDAE	*Leiostomus*	*xanthurus*	1	0.2
SYNODONTIDAE	*Synodus*	*foetens*	1	0.2
UNKNOWN	---	---	37	5.9
		Total	626	100.1

Table 9. Species list of larvae taken in bongo and neuston samples from the EPA field and control stations during all three cruises.

Family	Genus	Species
BALISTIDAE (triggerfishes and filefishes)	*Monacanthus*	*hispidus*
	Monacanthus	sp.
BELONIDAE (Needlefishes)	*Ablennes*	*hians*
BLENNIIDAE (combtooth blennies)	*Hypleurochilus*	*geminatus*
BOTHIDAE (lefteye flounders)	*Bothus*	*ocellatus*
	Bothus	sp.
	Cyclopsetta	*fimbriata*
	Cyclopsetta	sp.
	Monolene	sp.
	Paralichthys	sp.
	Syacium	*gunteri*
	Syacium	sp.
BREGMACEROTIDAE (codlets)	*Bregmaceros*	*atlanticus*
CARANGIDAE (jacks and pompanos)	*Alectis*	*crinitus*
	caranx	sp.
	chloroscombrus	*chrysurus*
	Decapterus	*punctatus*
	Selar	*crumenopthalmus*
	Trachurus	*lathami*
CLUPEIDAE (herrings)	*Brevoortia*	*patronus*
	Brevoortia	sp.
	Harengula	*jaguana*
	Opisthonema	*oglinum*
CYNOGLOSSIDAE (tonguefishes)	*Symphurus*	sp.
ENGRAULIDAE (anchovies)	*Anchoa*	sp.
	Engraulis	*eurystole*
EPHIPPIDAE (spadefishes)	*Chaetodipterus*	*faber*
EXOCOETIDAE (flyingfishes and halfbeaks)	*Cypselurus*	sp.
	Hirundichthys	*affinis*
	Parexocoetus	*brachypterus*

Table 9. (Continued)

Family	Genus	Species
	Prognichthys	gibbifrons
GADIDAE (codfishes)	Urophycis	sp.
GERREIDAE (mojarras)	Eucinostomus	sp.
GOBIIDAE (gobies)	--	--
GRAMMISTIDAE (soapfishes)	Rypticus	sp
ISTIOPHORIDAE (billfishes)	Istiophorus	platypterus
LUTJANIDAE (snappers)	Etelis Lutjanus Lutjanus	oculatus campechanus sp.
MICRODESMIDAE (wormfishes)	Microdesmus	sp.
MUGILIDAE (mullets)	Mugil	cephalus
MULLIDAE (goatfishes)	--	--
MURAENIDAE (morays)	Gymnothorax	sp.
MYCTOPHIDAE (lanternfishes)	Diaphus Notoscopelus	sp. resplendens
OGCOCEPHALIDAE (batfishes)	--	--
OPHICHTHIDAE (snake eels)	Myrophis	sp.
OPHIDIIDAE (cusk-eels and brotulas)	Rissola	marginata
POMADASYIDAE (grunts)	--	--

Table 9. (Continued)

Family	Genus	Species
PRIACANTHIDAE (bigeyes)	--	--
RACHYCENTRIDAE (cobias)	Rachycentron	canadum
SCIAENIDAE (drums)	Bairdiella	chrysura
	Cynoscion	nothus
	Cynoscion	sp.
	Larimus	fasciatus
	Leiostomus	xanthurus
	Menticirrhus	sp.
	Micropogon	undulatus
SCOMBRIDAE (mackerels and tunas)	Euthynnus	alletteratus
	Scomberomorus	cavalla
	Scomberomorus	maculatus
SCORPAENIDAE (scorpionfishes)	Scorpaena	sp.
SERRANIDAE (sea basses)	Centropristis	sp.
	Diplectrum	sp.
	Serraniculus	pumilio
SPARIDAE (porgies)	Lagodon	rhomboides
SPHYRAENIDAE (barracudas)	Sphyraena	sp.
STROMATEIDAE (butterfishes)	Peprilus	alepidotus
	Peprilus	burti
SYNODONTIDAE (lizardfishes)	Saurida	sp.
	Synodus	foetens
	Synodus	sp.
TETRAODONTIDAE (puffers)	Sphoeroides	sp.
TRIGLIDAE (searobins)	Prionotus	sp.
URANOSCOPIDAE (stargazers)	--	--

Table 10. Dominant larval families in descending order of abundance by gear type for all EPA stations during first cruise, July 13-14, 1977.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Engraulidae	41.3	Engraulidae	45.6	Engraulidae	48.9
Bothidae	26.7	Bothidae	16.8	Clupeidae	13.5
Clupeidae	5.2	Clupeidae	5.8	Bothidae	11.8
Gobiidae	4.5	Gobiidae	3.7	Exocoetidae	4.8
Serranidae	3.4	Microdesmidae	3.2	Gobiidae	4.4
Scombridae	2.6	Serranidae	2.9	Sciaenidae	3.7
Lutjanidae	2.5	Ophidiidae	2.0	Scombridae	2.1
Sciaenidae	2.2	Carangidae	1.8	Lutjanidae	1.7
Microdesmidae	1.7	Lutjanidae	1.8	Tetraodontidae	1.1
Cynoglossidae	1.4	Cynoglossidae	1.7	Serranidae	0.9
		Scombridae	1.7		
Total	91.5		87.0		92.9

Table 11. Dominant larval families in descending order of abundance by gear type for all EPA stations during second cruise, October 13-14, 1977.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Engraulidae	48.1	Engraulidae	43.0	Sciaenidae	59.2
Sciaenidae	1.9	Sciaenidae	39.1	Engraulidae	31.7
Gobiidae	2.3	Gobiidae	6.4	Gobiidae	2.2
Bothidae	1.9	Ophidiidae	4.2	Ophidiidae	1.6
Ophidiidae	1.2	Bothidae	2.4	Bothidae	1.4
Carangidae	0.8	Blenniidae	0.9	Carangidae	0.9
Ophichthidae	0.4	Carangidae	0.5	Clupeidae	0.4
Clupeidae	0.1	Cynoglossidae	0.3	Balistidae	0.3
Stromateidae	0.1	Clupeidae	0.2	Blenniidae	0.3
Uranoscopidae	0.1	Ophichthidae	0.2	Tetraodontidae	0.3
TOTAL	96.9		97.2		98.3

Table 12. Dominant larval families in descending order of abundance by gear type for all EPA stations during third cruise, February 20 and 22, 1978.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Clupeidae	41.9	Clupeidae	61.4	Clupeidae	68.1
Stromateidae	20.9	Pomadasyidae	9.6	Sparidae	13.8
Sparidae	10.5	Sparidae	6.4	Stromateidae	1.9
Carangidae	5.8	Bothidae	3.6	Bothidae	1.5
Serranidae	5.8	Stromateidae	3.2	Carangidae	1.5
Ophidiidae	2.3	Carangidae	2.5	Serranidae	1.5
Sciaenidae	2.3	Serranidae	2.1	Synodontidae	1.5
Bothidae	1.2	Sciaenidae	1.8	Blenniidae	0.8
Bregmacerotidae	1.2	Ophidiidae	1.1	Sciaenidae	0.8
Pomadasyidae	1.2	Triglidae	1.1		
Synodontidae	1.2				
Triglidae	1.2				
Total	95.5		92.8		91.4

Table 13 . Dominant larval families in descending order of abundance by gear type for all EPA stations during all three cruises from July 1977 to February 1978.

0.505 mm (Bongo)		0.333 mm (Bongo)		0.505 mm (Neuston)	
Family	%	Family	%	Family	%
Engraulidae	43.6	Engraulidae	40.8	Engraulidae	41.9
Sciaenidae	23.6	Sciaenidae	14.4	Sciaenidae	22.0
Bothidae	12.5	Bothidae	10.6	Clupeidae	10.6
Clupeidae	3.7	Clupeidae	8.5	Bothidae	8.1
Gobiidae	3.1	Gobiidae	4.3	Gobiidae	3.5
Serranidae	1.6	Ophidiidae	2.7	Exocoetidae	3.1
Scombridae	1.1	Serranidae	1.8	Scombridae	1.4
Lutjanidae	1.1	Microdesmidae	1.8	Lutjanidae	1.1
Carangidae	0.9	Carangidae	1.4	Serranidae	0.6
Ophidiidae	0.9	Lutjanidae	1.0	Ophidiidae	0.6
Total	92.1		87.3		92.9

Table 14. Diversity of larval fishes taken in bongo samples at Buccaneer oil field area stations from July 1977 to February 1978.

	July 1977			October 1977			February 1978			All cruises		
Stations	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.
Eight Platform (II and IV: A,B,C,D)	23	31	16	11	12	7	10	8	4	26	39	22
Eight Satellite (III and V: A,B,C,D)	23	27	15	12	10	6	12	11	8	29	38	24
Two outside - control (I and VI)	16	10	5	8	10	5	8	6	2	22	23	10
Total of all stations	25	33	18	14	13	7	14	13	8	31	43	26

Table 15. Size and abundance of the most dominant larvae, in decreasing order of abundance, taken in bongo nets at the platform stations during all three cruises.

Taxon	Size range (mm)	Mean size (mm)	Total number	% of total catch	Abundance in No./1,000 m^3		
					Jul.	Oct.	Feb.
ENGRAULIDAE	2.7-16.0	6.5	746	26.1	876	177	2
Anchoa sp.	5.9-20.0	12.8	252	8.8	272	101	
Engraulis eurystole	11.0-11.0	11.0	1	*	1		
SCIAENIDAE	2.8-3.0	2.9	2	.1	3		
Cynoscion nothus	3.0-7.8	5.9	16	.6	12	16	
Cynoscion sp.	2.0-6.0	3.8	209	7.3	16	442	
Larimus fasciatus	4.1-4.1	4.1	1	*		2	
Menticirrhus sp.	3.8-4.2	4.3	4	.1	2	4	
Micropogon undulatus	2.7-10.9	4.9	73	2.6		164	
BOTHIDAE	2.0-8.5	3.9	28	1.0	21	16	9
Bothus ocellatus	3.7-7.9	5.8	48	1.7	63		
Bothus sp.	4.3-4.3	4.3	1	*	1		
Cyclopsetta sp.	12.0-13.0	12.5	2	.1	3		
Monolene sp.	2.4-2.4	2.4	1	*	1		
Paralichthys sp.	9.7-9.7	9.7	1	*			2
Syacium gunteri	5.8-9.2	7.0	51	1.8	67		
Syacium sp.	1.4-6.8	4.5	170	5.9	223		
CLUPEIDAE	3.6-18.2	6.2	100	3.5	84		66
Brevoortia sp.	14.0-19.0	5.1	18	.6			33
Harengula jaguana	10.0-24.0	15.5	38	1.3	50		
Opisthonema oglinum	8.7-8.8	8.8	2	.1	3		
GOBIIDAE	2.3-9.8	6.9	83	2.9	104	9	
SERRANIDAE	1.7-3.9	2.4	4	.1	4		2
Centropristis sp.	3.3-6.0	4.8	6	.2			6
Diplectrum sp.	2.0-4.2	3.4	40	1.4	52		
Serraniculus pumilio	2.7-5.3	3.3	16	.6	21		
CARANGIDAE	1.7-4.8	3.3	16	.6	21		
Chloroscombrus chrysurus	4.6-4.8	4.7	2	.1	3		
Decapterus punctatus	3.7-3.7	3.7	1	*	1		
Trachurus lathami	4.1-5.1	3.3	16	.6			16
MICRODESMIDAE							
Microdesmus sp.	1.8-20.0	8.8	29	1.0	38		
OPHIDIIDAE	2.6-15.0	4.4	9	.3	20	2	
Rissola marginata	3.8-8.0	5.3	3	.1		4	2
LUTJANIDAE	3.4-5.2	3.8	6	.2	8		
Etelis oculatus	4.2-4.2	4.2	1	*	1		
Lutjanus campechanus	4.3-2.2	4.9	14	.5	18		

* Value less than 0.05

Table 16. Size and abundance of the most dominant larvae, in decreasing order of abundance, taken in bongo nets at the satellite stations during all three cruises.

Taxon	Size range (mm)	Mean size (mm)	Total number	% of total catch	Abundance in No./1,000 m^3 Jul.	Oct.	Feb.
ENGRAULIDAE	2.1-17.5	6.4	792	32.5	297	1128	
Anchoa sp.	6.5-20.0	11.3	327	13.4	34	664	
Engraulis eurystole	8.5-14.0	10.4	5	.2	5		
SCIAENIDAE	2.8-3.3	3.1	12	.5	1	20	4
Cynoscion nothus	3.7-9.5	5.7	10	.4	8	5	
Cynoscion sp.	2.2-6.5	3.5	134	5.5	3	297	
Larimus fasciatus	6.5-6.5	6.5	1	*		2	
Menticirrhus	2.6-3.2	2.9	3	.1	2	2	
Micropogon undulatus	2.2-8.3	2.9	274	11.2		618	2
BOTHIDAE	2.0-10.4	5.7	36	1.5	16	36	6
Bothus ocellatus	3.8-10.3	5.3	35	1.4	35		
Bothus sp.	3.3-4.7	4.4	4	.2	4		
Cyclopsetta fimbriata	14.9-14.9	14.9	1	*	1		
Cyclopsetta sp.	7.4-7.4	7.4	1	*	1		
Paralichthys sp.	3.4-3.4	3.4	1	*			2
Syacium gunteri	6.0-11.3	7.5	48	2.0	48	2	
Syacium sp.	1.2-9.0	4.6	95	3.9	84	27	
CLUPEIDAE	2.9-9.1	5.2	132	5.4	43	7	168
Brevoortia patronus	18.2-18.2	18.2	1	*			2
Brevoortia sp.	4.4-14.0	7.2	12	.5			23
Harengula jaguana	7.3-22.5	14.8	11	.5	11		
Opisthonema oglinum	9.5-13.3	11.2	3	.1	3		
GOBIIDAE	1.8-10.0	5.8	97	4.0	31	150	
LUTJANIDAE	3.1-4.4	3.7	17	.8	17		
Etelis oculatus	3.6-3.6	3.6	1	*	2		
Lutjanus campechanus	4.2-6.6	5.1	20	.8	20		
MICRODESMIDAE							
Microdesmus sp.	2.3-13.8	4.9	38	1.6	38		
OPHIDIIDAE	3.4-36.0	12.7	10	.4	4	14	
Rissola marginata	2.2-8.0	3.2	26	1.1		52	6
CARANGIDAE	2.9-18.0	4.7	13	.5	4		
Caranx sp.	5.8-6.5	6.2	2	.1	2		
Chloroscombrus chrysurus	4.7-8.0	6.0	6	.2	4	5	
Trachurus lathami	3.2-4.2	3.6	3	.1			6
SERRANIDAE	1.7-6.2	2.9	8	.3	8		
Centropristis sp.	4.3-4.7	4.6	3	.1			6
Diplectrum sp.	2.5-8.7	4.5	7	.3	7		
Serraniculus pumilio	1.9-3.4	2.7	5	.2	5	20	

* Value less than 0.05

Table 17. Size and abundance of the most dominant larvae, in decreasing order of abundance, taken in bongo nets at all Buccaneer oil field stations during all three cruises.

Taxon	Size range (mm)	Mean size (mm)	Total number	% of total catch	Abundance in No./1,000 m^3 Jul.	Oct.	Feb.
ENGRAULIDAE	2.0-17.5	6.3	1799	30.6	524	730	1
Anchoa sp.	6.5-27.0	12.6	633	10.8	120	415	0
Engraulis eurystole	8.5-14.0	10.5	6	0.1	3	0	0
SCIAENIDAE	2.0-3.3	2.7	23	0.4	2	15	4
Cynoscion nothus	3.0-9.5	5.9	28	0.5	8	11	0
Cynoscion sp.	2.0-6.5	3.8	521	8.9	7	498	0
Larimus fasciatus	4.1-6.5	4.9	5	0.1	1	4	0
Menticirrhus sp.	2.5-4.9	3.5	10	0.2	2	6	0
Micropogon undulatus	2.0-10.9	4.5	493	8.4	0	483	2
BOTHIDAE	2.0-11.0	5.8	75	1.3	16	33	8
Bothus ocellatus	3.7-10.3	5.6	84	1.4	42	0	0
Bothus sp.	2.4-4.3	3.5	5	0.1	3	0	0
Cyclopsetta fimbriata	14.9	14.9	1	*	1	0	0
Cyclopsetta sp.	7.4-13.0	10.8	3	0.1	2	0	0
Monolene sp.	2.4	2.4	1	*	1	0	0
Paralichthys sp.	3.4-9.7	6.5	2	*	0	0	
Syacium gunteri	5.8-11.3	7.3	108	1.8	52	3	0
Syacium sp.	1.2-9.0	4.1	392	6.7	186	18	0
CLUPEIDAE	2.9-12.3	5.1	285	4.9	56	3	145
Brevoortia patronus	18.2	18.2	1	*	0	0	1
Brevoortia sp.	4.4-19.0	12.4	37	0.6	0	0	32
Harengula jaguana	7.3-24.0	15.5	49	0.8	24	0	0
Opisthonema oglinum	8.7-13.3	10.1	5	0.1	3	0	0
GOBIIDAE	1.6-10.0	4.4	224	3.8	59	104	0
OPHIDIIDAE	2.3-40.0	4.1	53	0.9	21	10	0
Rissola marginata	2.2-8.0	3.2	61	1.0	0	55	4
SERRANIDAE	1.7-6.2	2.5	20	0.3	9	0	2
Centropristis sp.	3.3-6.0	4.7	9	0.2	0	0	8
Diplectrum sp.	2.0-9.1	3.6	53	0.9	26	0	0
Serraniculus pumilio	1.9-5.3	3.1	21	0.4	10	0	0
CARANGIDAE	1.7-4.8	2.9	41	0.7	16	9	0
Caranx sp.	5.8-6.5	6.1	2	*	1	0	0
Chloroscombrus chrysurus	4.6-18.0	6.9	14	0.2	3	8	0
Decapterus punctatus	3.7	3.7	1	*	1	0	0
Trachurus lathami	3.2-5.1	4.2	12	0.2	0	0	0
MICRODESMIDAE							
Microdesmus sp.	1.8-20.0	6.1	79	1.3	39	0	0
LUTJANIDAE	3.1-5.2	3.8	23	0.4	11	0	0
Etelis oculatus	3.6-4.9	4.2	3	0.1	1	0	0
Lutjanus campechanus	4.2-7.2	5.0	34	0.6	17	0	0

* Value less than 0.05

Table 18. Relative abundance of the most dominant larvae, in decreasing order of abundance, collected at all EPA stations from July 1977 to February 1978 in bongo tows.

Taxon	No.	% of total bongo catch	No. in family	% of total bongo catch
ENGRAULIDAE	1799	30.6	2438	41.5
Anchoa sp.	633	10.8		
Engraulis eurystole	6	0.1		
SCIAENIDAE	23	0.4	1080	18.4
Cynoscion nothus	28	0.5		
Cynoscion sp.	521	8.9		
Larimus fasciatus	5	0.1		
Menticirrhus sp.	10	0.2		
Micropogon undulatus	493	8.4		
BOTHIDAE	75	1.3	671	11.4
Bothus ocellatus	84	1.4		
Bothus sp.	5	0.1		
Cyclopsetta fimbriata	1	*		
Cyclopsetta sp.	3	0.1		
Monolene sp.	1	*		
Paralichthys sp.	2	*		
Syacium gunteri	108	1.8		
Syacium sp.	392	6.7		
CLUPEIDAE	285	4.9	377	6.4
Brevoortia patronus	1	*		
Brevoortia sp.	37	0.6		
Harengula jaguana	49	0.8		
Opisthonema oglinum	5	0.1		
GOBIIDAE	224	3.8	224	3.8
OPHIDIIDAE	53	0.9	114	1.9
Rissola marginata	61	1.0		
SERRANIDAE	20	0.3	103	1.8
Centropristis sp.	9	0.2		
Diplectrum sp.	53	0.9		
Serraniculus pumilio	21	0.4		
MICRODESMIDAE			79	1.3
Microdesmus sp.	79	1.3		
CARANGIDAE	41	0.7	70	1.2
Caranx sp.	2	*		
Chloroscombrus chrysurus	14	0.2		
Decapterus punctatus	1	*		
Trachurus lathami	12	0.2		
LUTJANIDAE	23	0.4	60	1.0
Etelis oculatus	3	0.1		
Lutjanus campechanus	34	0.6		

* Value less than 0.05

Table 19. Relative abundance of the most dominant larvae, in decreasing order of abundance, collected at all EPA stations from July 1977 to February 1978 in neuston tows.

Taxon	No.	% of total neuston catch	No. in family	% of total neuston catch
ENGRAULIDAE	3994	40.6	4120	41.9
Anchoa sp.	85	0.9		
Engraulis eurystole	41	0.4		
SCIAENIDAE	23	0.2	2165	22.0
Bairdiella chrysura	1	*		
Cynoscion nothus	183	1.9		
Cynoscion sp.	933	9.5		
Larimus fasciatus	6	0.1		
Leiostomus xanthurus	1	*		
Menticirrhus sp.	100	1.0		
Micropogon undulatus	918	9.3		
CLUPEIDAE	552	5.6	1043	10.6
Brevoortia sp.	147	1.5		
Harengula jaguana	327	3.3		
Opisthonema oglinum	17	0.2		
BOTHIDAE	197	2.0	792	8.1
Bothus ocellatus	59	0.6		
Bothus sp.	2	*		
Cyclopsetta sp.	1	*		
Paralichthys sp.	3	*		
Syacium gunteri	68	0.7		
Syacium sp.	462	4.7		
GOBIIDAE	349	3.5	349	3.5
EXOCOETIDAE	282	2.9	304	3.1
Cypselurus sp.	2	*		
Hirundichthys affinis	4	*		
Parexocoetus brachypterus	9	0.1		
Prognichthys gibbifrons	7	0.1		
SCOMBRIDAE	12	0.1	137	1.4
Euthynnus alletteratus	75	0.8		
Scomberomorus cavalla	43	0.4		
Scomberomorus maculatus	7	0.1		
LUTJANIDAE	49	0.5	107	1.1
Lutjanus campechanus	58	0.6		
SERRANIDAE	7	0.1	59	0.6
Centropristis sp.	4	*		
Diplectrum sp.	13	0.1		
Serraniculus pumilio	35	0.4		
OPHIDIIDAE	9	0.1	59	0.6
Rissola marginata	50	0.5		

* Value less than 0.05

Table 20. Selected larval and juvenile fishes of recreational and/or commercial value taken in the neuston net during all three cruises.

Taxon	Size range (mm)	Mean size (mm)	Total No.	Occurrence		
				Jul.	Oct.	Feb.
EPHIPPIDAE						
Chaetodipterus faber	6.0-9.2	8.0	4	X		
ISTIOPHORIDAE						
Istiophorus platypterus	24.0-25.0	25.0	2	X		
LUTJANIDAE	2.9-6.5	3.6	49	X		
Lutjanus campechanus	3.7-5.9	4.5	58	X		
MUGILIDAE						
Mugil cephalus	24.0	24.0	1			X
RACHYCENTRIDAE						
Rachycentron canadum	5.9-23.0	14.8	6	X		
SCIAENIDAE	2.0-3.6	2.6	22		X	
Cynoscion nothus	2.3-6.3	4.2	183	X		
Cynoscion sp.	2.2-5.8	3.8	933	X	X	
Micropogon undulatus	2.3-7.8	4.5	918		X	
SCOMBRIDAE	3.0-4.5	3.7	12	X		
Euthynnus alletteratus	3.0-6.8	4.4	75	X		
Scomberomorus cavalla	2.8-5.9	4.0	43	X	X	
Scomberomorus maculatus	2.2-16.0	4.7	7	X	X	
SPHYRAENIDAE						
Sphyraena sp.	3.4-5.6	4.2	4	X		

Table 21. Abundance of fish larvae from all bongo samples collected at the platform and satellite stations from July 1977 to February 1978.

	July 1977			October 1977			February 1978		
Station	No.	% of total catch	No./ 1,000 m^3	No.	% of total catch	No./ 1,000 m^3	No.	% of total catch	No./ 1,000 m^3
Platform									
(II)	146	5.6	339	650	27.0	3,116	31	10.5	82
(IV)	1,598	61.5	4,813	346	14.4	1,462	89	30.2	345
Totals	1,744	67.1	2,288	996	41.4	2,237	120	40.7	189
Satellite									
(III)	217	8.3	392	1,241	51.6	5,695	108	36.6	410
(V)	638	24.5	1,466	166	6.9	743	67	22.7	271
Totals	855	32.9	864	1,407	58.6	3,188	175	59.3	342

Table 22. Abundance of fish eggs from all bongo samples collected at the platform and satellite stations from July 1977 to February 1978.

	July 1977			October 1977			February 1978		
Station	No.	% of total catch	No./ 1,000 m^3	No.	% of total catch	No./ 1,000 m^3	No.	% of total catch	No./ 1,000 m^3
Platform									
(II)	39	1.4	91	31	11.6	149	13	13.5	34
(IV)	1,498	51.9	4,512	44	16.4	186	34	35.4	132
Totals	1,537	53.3	2,017	75	28.0	168	47	48.9	74
Satellite									
(III)	264	9.1	477	154	57.5	707	30	31.3	114
(V)	1,087	37.6	2,498	39	14.6	174	19	19.8	77
Totals	1,351	46.7	1,366	193	72.1	437	49	51.1	96

Table 23. Comparison of egg and larval abundance from bongo tows at two EPA field stations between the 1976-77 and 1977-78 studies.

			1976-77						1977-78			
			Eggs		Larvae				Eggs		Larvae	
Sampling Season	Station	Date and time (CST)	No./ 1,000 m^3	No. under 10 m^2	No./ 1,000 m^3	No. under 10 m^2	Station	Date and time (CST)	No./ 1,000 m^3	No. under 10 m^2	No./ 1,000 m^3	No./ under 10 m^2
Summer	"B" *	8/16/76 (2200)	4,703	659	2,458	344	III-D	7/14/77 (1422)	368	52	373	52
	"G"	8/17/76 (1330)	3,769	528	1,760	246	IV-D	7/13/77 (2130)	16,742	2,344	5,497	770
Fall	"B"	12/4/76 (1137)	2,367	331	347	49	III-D	10/14/77 (0100)	507	71	3,152	441
	"G"	12/3/76 (1959)	371	52	1,036	145	IV-D	10/14/77 (1634)	103	15	1,360	190
Winter	"B"	2/19/77 (1212)	199	28	133	19	III-D	2/22/78 (1227)	117	16	616	86
	"G"	2/19/77 (1605)	137	19	55	8	IV-D	2/22/78 (1341)	228	32	379	53
Spring	"B"	5/24/76 (1950)	17,589	2,463	446	63	(NO SAMPLING DONE DURING THIS PERIOD.)					
	"G"	5/25/76 (1300)	8,526	1,194	560	78						

* Stations "B" and "G" from the 1976-77 study are located approximately 0.7 nautical miles (1.3 km) apart from 1977-78 stations III-D and IV-D, respectively, in the Buccaneer oil field.

Table 24. Comparison of egg and larval abundance from bongo tows at two EPA control stations (outside the field area) between the 1976-77 and 1977-78 studies.

	1976-77						1977-78					
			Eggs		Larvae				Eggs		Larvae	
Sampling Season	Station	Date and time (CST)	No./ 1,000 m^3	No. under 10 m^2	No./ 1,000 m^3	No. under 10 m^2	Station	Date and time (CST)	No./ 1,000 m^3	No. under 10 m^2	No./ 1,000 m^3	No. under 10 m^2
Summer	"E" *	8/17/76 (1640)	4,579	641	766	769	I	7/14/77 (1900)	343	48	1,352	189
	"H"	8/17/76 (1200)	10,103	1,414	722	101	VI	7/14/77 (1200)	3,208	449	1,495	209
Fall	"E"	12/3/76 (2154)	56	8	592	83	I	10/13/77 (1945)	1,006	141	1,230	172
	"H"	12/3/76 (1820)	478	63	621	87	VI	10/14/77 (1040)	204	29	902	126
Winter	"E"	2/19/77 (1405)	123	17	139	19	I	2/20/78 (1555)	76	11	0	0
	"H"	2/19/77 (1723)	199	28	329	46	VI	2/22/78 (1850)	650	91	1,377	193
Spring	"E"	5/25/76 (1115)	6,364	891	227	32	(NO SAMPLING DONE DURING THIS PERIOD.)					
	"H"	5/25/76 (1400)	9,856	1,380	164	23						

* Stations "E" and "H" from the 1976-77 study are the same as 1977-78 study stations I and VI, respectively.

Table 25. Comparison of fish egg and larval abundance from bongo net samples at selected EPA and BLM stations from May 1977 to October 1977.

	EPA				BLM			
	II-D	III-D	IV-D	V-D	I-1	II-1	III-1	IV-1
EGGS								
May 1977:								
No./1,000 m^3	(NO SAMPLING DONE)				761	1,808	2,256	5,945
No. under 10 m^2					99	307	451	1,308
July 1977:								
No./1,000 m^3	285	368	16,742	946	(NO SAMPLING DONE)			
No./ under 10 m^2	40	52	2,344	132				
Sept. 1977:								
No./1,000 m^3	(NO SAMPLING DONE)				229	931	104	1,209
No. under 10 m^2					30	158	21	266
Oct. 1977:								
No./1,000 m^3	160	507	103	92	(NO SAMPLING DONE)			
No. under 10 m^2	23	71	15	13				
LARVAE								
May 1977:								
No./1,000 m^3	(NO SAMPLING DONE)				788	5,972	685	2,224
No. under 10 m^2					103	1,015	137	489
July 1977:								
No./1,000 m^3	335	373	5,492	1,961	(NO SAMPLING DONE)			
No. under 10 m^2	47	52	770	275				
Sept. 1977:								
No/1,000 m^3	(NO SAMPLING DONE)				4,098	2,075	1,151	2,987
No. under 10 m^2					533	353	230	370
Oct. 1977:								
No./1,000 m^3	2,834	3,152	1,360	591	(NO SAMPLING DONE)			
No. under 10 m^2	397	441	190	83				

* From .505 mm and .333 mm mesh-nets combined.

Table 26. Temperature and salinity ranges for the most abundant families from all larval collections.

Taxon	Temperature Range (°C)	Salinity Range(°/oo)
ENGRAULIDAE	12.0-26.0	32.0-36.0
Anchoa sp.	23.0-26.0	32.0-36.0
Engraulis eurystole	23.0-24.8	33.0-35.5
SCIAENIDAE	11.0-26.0	32.0-35.5
Bairdiella chrysura	23.9-24.9	33.0-33.5
Cynoscion nothus	23.0-26.0	32.0-35.5
Cynoscion sp.	23.0-26.0	32.0-36.0
Larimus fasciatus	23.0-25.5	32.0-35.5
Leiostomus xanthurus	12.0-12.0	34.0-34.0
Menticirrhus sp.	23.0-26.0	32.0-36.0
Micropogon undulatus	10.8-26.0	31.9-36.0
BOTHIDAE	11.0-26.0	32.0-36.0
Bothus ocellatus	23.0-24.9	32.8-36.0
Bothus sp.	23.2-25.5	32.0-36.0
Cyclopsetta fimbriata	23.0-24.8	33.0-33.5
Cyclopsetta sp.	23.0-24.5	33.0-34.0
Monolene sp.	24.5-25.0	34.5-35.0
Paralichthys sp.	10.8-12.2	31.9-34.0
Syacium gunteri	23.0-26.0	32.8-36.0
Syacium sp.	23.0-26.0	32.0-36.0
CLUPEIDAE	10.8-26.0	31.9-36.0
Brevoortia patronus	10.8-12.3	31.9-35.1
Brevoortia sp.	10.8-12.5	31.9-35.5
Harengula jaguana	23.0-24.9	32.8-34.0
Opisthonema oglinum	23.0-25.5	32.8-36.0
GOBIIDAE	23.0-26.0	32.0-36.0
EXOCOETIDAE	23.0-26.0	33.0-36.0
Cypselurus sp.	23.8-25.5	33.0-35.5
Hirundichthys affinis	24.0-25.5	34.9-36.0
Parexocoetus brachypterus	23.0-25.8	32.0-36.0
Prognichthys gibbifrons	23.0-25.5	33.0-34.0
SCOMBRIDAE	23.0-25.5	32.8-34.0
Euthynnus alletteratus	23.0-26.0	32.8-35.5
Scomberomorus cavalla	23.0-26.0	32.0-36.0
Scomberomorus maculatus	23.0-24.9	32.0-33.8
OPHIDIIDAE	11.1-26.0	32.0-36.0
Rissola marginata	10.8-25.5	31.9-35.5
LUTJANIDAE	23.0-26.0	32.8-35.0
Etelis oculatus	23.4-25.8	33.0-35.5
Lutjanus campechanus	23.0-25.8	32.8-35.5
SERRANIDAE	11.0-26.0	32.0-36.0
Centropristis sp.	11.1-12.8	32.8-35.5
Diplectrum sp.	23.0-26.0	32.8-36.0
Serraniculus pumilio	23.0-26.0	32.8-36.0

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Table 27. Distribution of fish larvae taken in bongo and neuston samples from all Buccaneer oil field stations by family, genus, and species from July 1977 to February 1978.

	Platform stations		Satellite stations		Outside-control stations	
Taxon	II(A-D)	IV(A-D)	III(A-D)	V(A-D)	I	VI
BALISTIDAE						
Monacanthus hispidus			X			
Monacanthus sp.		X		X		
BELONIDAE	X	X				
Ablennes hians	X					
BLENNIIDAE	X	X	X	X	X	X
Hypleurochilus geminatus		X		X		X
BOTHIDAE	X	X	X	X	X	X
Bothus ocellatus		X		X	X	
Bothus sp.		X	X	X	X	X
Cyclopsetta fimbriata				X		
Cyclopsetta sp.		X		X		
Monolene sp.	X					
Paralichthys sp.	X	X		X		
Syacium gunteri	X	X	X	X	X	X
Syacium sp.	X	X	X	X	X	X
BREGMACEROTIDAE						
Bregmaceros atlanticus			X	X		
CARANGIDAE	X	X	X	X	X	X
Alectis crinitus	X					
Caranx sp.			X	X		
Chloroscombrus chrysurus	X	X	X	X		X
Decapterus punctatus	X	X		X		
Selar crumenophthalmus				X		
Trachurus lathami	X	X	X	X		
CLUPEIDAE	X	X	X	X	X	X
Brevoortia patronus			X			
Brevoortia sp.	X	X	X	X	X	X
Harengula jaguana	X	X	X	X		
Opisthonema oglinum	X	X		X		
CYNOGLOSSIDAE						
Symphurus sp.	X	X	X	X	X	X
ENGRAULIDAE	X	X	X	X	X	X
Anchoa sp.	X	X	X	X	X	X
Engraulis eurystole	X	X		X		
EPHIPPIDAE						
Chaetodipterus faber		X		X		
EXOCOETIDAE	X	X	X	X	X	X
Cypselurus sp.	X	X				
Hirundichthys affinis	X				X	
Parexocoetus brachypterus			X		X	
Prognichthys gibbifrons	X	X		X		X

Table 27. (Continued)

Taxon	Platform stations II(A-D)	Platform stations IV(A-D)	Satellite stations III(A-D)	Satellite stations V(A-D)	Outside-control stations I	Outside-control stations VI
GADIDAE						
Urophycis sp.						X
GERREIDAE		X		X		X
Eucinostomus sp.	X	X		X		X
GOBIIDAE	X	X	X	X	X	X
GRAMMISTIDAE						
Rypticus sp.		X		X		
ISTIOPHORIDAE						
Istiophorus platypterus				X		
LUTJANIDAE	X	X	X	X		
Etelis oculatus	X		X			X
Lutjanus campechanus		X	X	X		
MICRODESMIDAE						
Microdesmus sp.	X	X	X	X	X	X
MUGILIDAE						
Mugil cephalus			X			
MULLIDAE	X	X	X	X		
MURAENIDAE		X				X
Gymnothorax sp.	X	X	X	X		
MYCTOPHIDAE						
Diaphus sp.			X			
Notoscopelus resplendens			X			
OGCOCEPHALIDAE	X	X	X	X		
OPHICHTHIDAE	X	X	X	X		
Myrophis sp.	X	X	X	X		X
OPHIDIIDAE	X	X	X	X	X	X
Rissola marginata	X	X	X	X	X	X
POMADASYIDAE	X	X	X	X		
PRIACANTHIDAE				X		
RACHYCENTRIDAE						
Rachycentron canadum	X	X		X		
SCIAENIDAE	X	X	X	X	X	X
Bairdiella chrysura		X				
Cynoscion nothus	X	X	X	X		
Cynoscion sp.	X	X	X	X	X	X
Larimus fasciatus	X	X	X	X	X	
Leiostomus xanthurus	X					
Menticirrhus sp.	X	X	X	X	X	
Micropogon undulatus	X	X	X	X	X	X
SCOMBRIDAE		X		X		X
Euthynnus alletteratus		X	X	X		X
Scomberomorus cavalla	X	X	X	X		X
Scomberomorus maculatus		X	X	X		
SCORPAENIDAE						
Scorpaena sp.		X	X	X	X	

Table 27. (Continued)

Taxon	Platform stations II(A-D)	Platform stations IV(A-D)	Satellite stations III(A-D)	Satellite stations V(A-D)	Outside-control stations I	Outside-control stations VI
SERRANIDAE	X	X	X	X	X	X
Centropristis sp.	X	X	X	X		
Diplectrum sp.	X	X	X	X		X
Serraniculus pumilio	X	X	X	X		
SPARIDAE	X	X	X	X		
Lagodon rhomboides	X	X	X			
SPHYRAENIDAE						
Sphyraena sp.				X		
STROMATEIDAE						
Peprilus alepidotus	X		X			
Peprilus burti	X	X	X	X		X
SYNODONTIDAE				X		
Saurida sp.	X			X		X
Synodus foetens		X		X		
Synodus sp.				X		
TETRAODONTIDAE		X			X	
Sphoeroides sp.	X	X	X	X	X	
TRIGLIDAE						
Prionotus sp.	X	X	X	X		X
URANOSCOPIDAE			X			

Table 28. Comparison of egg abundance and distribution by taxon between EPA platform and satellite stations by cruise from July 1977 to February 1978 taken from 0.333 mm bongo samples.

Taxon	Date	Field stations: platform (II and IV) No./1,000 m^3 A	B	C	D*	Total	Control stations: satellite (III and V) No./1,000 m^3 A	B	C	D	Total
Anguilliformes	July 1977	0	0	0	14	3	0	12	36	6	8
Callionymidae		15	0	0	14	5	0	0	0	0	0
Clupeidae		0	0	0	0	0	0	0	0	0	0
Engraulidae		0	0	103	2402	455	5	12	73	26	20
Sciaendiae		0	0	760	7931	1606	0	0	218	0	24
Scombridae		15	0	10	43	13	0	0	0	0	0
Soleidae		0	0	0	0	0	0	0	0	0	0
Anguilliformes	October 1977	18	0	0	17	9	0	0	0	0	0
Callionymidae		0	0	0	0	0	0	0	0	0	0
Clupeidae		0	0	19	0	4	171	114	70	70	107
Engraulidae		0	0	0	0	0	0	0	0	0	0
Sciaenidae		0	0	0	0	0	0	0	0	0	0
Scombridae		0	0	0	0	0	0	0	0	0	0
Soleidae		53	0	0	17	17	0	0	0	0	0
Anguilliformes	February 1978	0	0	0	0	0	0	0	0	0	0
Callionymidae		0	0	0	0	0	0	0	0	0	0
Clupeidae		0	0	0	35	13	0	0	42	0	11
Engraulidae		0	15	31	17	17	0	31	14	44	22
Sciaenidae		0	0	0	0	0	0	0	0	0	0
Scombridae		0	0	0	0	0	0	0	0	0	0
Soleidae		0	0	0	0	0	0	0	0	0	0

* Brine discharge side

Table 29. Identification and calculated numbers of EPA ichthyoplankton obtained from bongo samples by date, station and mesh size.

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	I	505	21	Bothidae - *Syacium* sp.	394
				Bothidae - *Syacium gunteri*	21
				Carangidae	11
				Cynoglossidae - *Symphurus* sp.	11
				Engraulidae	75
				Microdesmidae - *Microdesmus* sp.	21
				Ophidiidae	21
				Scorpaenidae - *Scorpaena* sp.	11
				Unknown	64
7/14	I	333	642	Blenniidae	10
				Bothidae	10
				Bothidae - *Bothus* sp.	20
				Bothidae - *Bothus ocellatus*	10
				Bothidae - *Syacium* sp.	692
				Bothidae - *Syacium gunteri*	20
				Carangidae	99
				Clupeidae	20
				Cynoglossidae - *Symphurus* sp.	59
				Engraulidae	474
				Gobiidae	79
				Microdesmidae - *Microdesmus* sp.	59
				Ophidiidae	208
				Scorpaenidae - *Scorpaena* sp.	49
				Serranidae	69
				Tetraodontidae	10
				Unknown	138

Table 29. (Continued)

Date (1977)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	II-A	505	0	Bothidae - *Syacium* sp.	244
				Bothidae - *Syacium gunteri*	41
				Clupeidae - *Opisthonema oglinum*	41
				Gobiidae	81
				Muraenidae - *Gymnothorax* sp.	41
				Sciaenidae - *Larimus fasciatus*	41
				Serranidae - *Diplectrum* sp.	41
				Unknown	81
7/14	II-A	333	390	Bothidae	87
				Bothidae - *Monolene* sp.	43
				Bothidae - *Syacium* sp.	346
				Bothidae - *Syacium gunteri*	87
				Carangidae - *Chloroscombrus chrysurus*	43
				Clupeidae	87
				Cynoglossidae - *Symphurus* sp.	43
				Engraulidae	303
				Gobiidae	87
				Lutjanidae	43
				Microdesmidae - *Microdesmus* sp.	43
				Ophidiidae	43
				Serranidae - *Diplectrum* sp.	260
				Serranidae - *Serraniculus pumilio*	43
				Synodontidae - *Saurida* sp.	43
				Unknown	173
7/14	II-B	505	0	Bothidae - *Syacium gunteri*	29
				Engraulidae	10
				Gobiidae	10
				Ogcocephalidae	10

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	II-B	333	81	Bothidae - *Syacium* sp.	27
				Bothidae - *Syacium gunteri*	36
				Clupeidae	27
				Engraulidae	27
				Engraulidae - *Anchoa* sp.	45
				Microdesmidae - *Microdesmus* sp.	45
				Muraenidae - *Gymnothorax* sp.	9
				Scombridae - *Scomberomorus cavalla*	9
				Unknown	18
7/14	II-C	505	0	Bothidae - *Syacium* sp.	57
				Bothidae - *Syacium gunteri*	57
				Carangidae	19
				Engraulidae	38
				Gobiidae	19
				Microdesmidae - *Microdesmus* sp.	38
				Ophidiidae	19
				Serranidae - *Diplectrum* sp.	19
				Unknown	19
7/14	II-C	333	75	Bothidae	19
				Bothidae - *Syacium* sp.	37
				Bothidae - *Syacium gunteri*	131
				Clupeidae	19
				Engraulidae	37
				Engraulidae - *Anchoa* sp.	37
				Microdesmidae - *Microdesmus* sp.	75
				Ogcocephalidae	19
				Serranidae	19
				Unknown	19

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	II-D	505	33	Bothidae - *Syacium* sp.	100
				Clupeidae	100
				Clupeidae - *Opisthonema oglinum*	33
				Engraulidae	33
				Lutjanidae - *Etelis oculatus*	33
				Tetraodontidae - *Sphoeroides* sp.	33
				Unknown	33
7/14	II-D	333	537	Bothidae - *Syacium* sp.	34
				Carangidae - *Chloroscombrus chrysurus*	34
				Clupeidae	67
				Cynoglossidae - *Symphurus* sp.	34
				Engraulidae	34
				Gerreidae - *Eucinostomus* sp.	34
				Microdesmidae - *Microdesmus* sp.	34
				Serranidae	34
7/14	III-A	505	75	Bothidae - *Syacium* sp.	47
				Bothidae - *Syacium gunteri*	38
				Clupeidae	9
				Cynoglossidae - *Symphurus* sp.	9
				Engraulidae	9
				Microdesmidae - *Microdesmus* sp.	19
				Ogcocephalidae	9
				Sciaenidae	9
				Tetraodontidae - *Sphoeroides* sp.	9
7/14	III-A	333	602	Bothidae - *Syacium* sp.	28
				Bothidae - *Syacium gunteri*	9
				Clupeidae	9

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	III-A	333		Cynoglossidae - *Symphurus* sp.	9
				Engraulidae	74
				Microdesmidae - *Microdesmus* sp.	65
				Serranidae	19
				Serranidae - *Serraniculus pumilio*	9
				Unknown	28
7/14	III-B	505	220	Bothidae - *Syacium* sp.	88
				Bothidae - *Syacium gunteri*	44
				Engraulidae	44
				Lutjanidae	22
				Lutjanidae - *Lutjanus campechanus*	22
				Microdesmidae - *Microdesmus* sp	44
				Scorpaenidae - *Scorpaena* sp.	22
7/14	III-B	333	1,138	Blenniidae	67
				Bothidae - *Syacium* sp.	67
				Bothidae - *Syacium gunteri*	45
				Carangidae - *Caranx* sp.	22
				Clupeidae	67
				Cynoglossidae - *Symphurus* sp.	67
				Engraulidae	201
				Lutjanidae - *Lutjanus campechanus*	22
				Microdesmidae - *Microdesmus* sp.	22
				Scombridae - *Euthynnus alletteratus*	22
				Serranidae	22
7/14	III-C	505	1,393	Bothidae	82
				Bothidae - *Syacium* sp.	492
				Cynoglossidae - *Symphurus* sp.	164

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	III-C	505		Engraulidae	246
				Gobiidae	82
				Ogcocephalidae	164
				Ophidiidae	82
				Sciaenidae - *Cynoscion* sp.	82
				Serranidae - *Diplectrum* sp.	164
7/14	III-C	333	2,479	Blenniidae	165
				Bothidae - *Syacium* sp.	248
				Engraulidae	909
				Microdesmidae - *Microdesmus* sp.	331
				Muraenidae - *Gymnothorax* sp.	83
				Scombridae - *Scomberomorus cavalla*	165
				Serranidae - *Serraniculus pumilio*	83
				Unknown	165
7/14	III-D	505	155	Bothidae - *Syacium* sp.	46
				Bothidae - *Syacium gunteri*	46
				Engraulidae	27
				Lutjanidae - *Etelis oculatus*	9
				Lutjanidae - *Lutjanus campechanus*	9
				Microdesmidae - *Microdesmus* sp.	27
				Ophichthidae - *Myrophis* sp.	9
				Scombridae - *Euthynnus alletteratus*	9
				Scombridae - *Scomberomorus cavalla*	9
7/14	III-D	333	572	Blenniidae	17
				Bothidae - *Syacium* sp.	104
				Bothidae - *Syacium gunteri*	9
				Clupeidae	17

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	III-D	333		Cynoglossidae - Symphurus sp.	26
				Engraulidae	199
				Engraulidae - Anchoa sp.	9
				Lutjanidae - Lutjanus campechanus	9
				Microdesmidae - Microdesmus sp.	52
				Ophidiidae	9
				Serranidae	17
				Serranidae - Diplectrum sp.	9
				Serranidae - Serraniculus pumilio	9
				Tetraodontidae - Sphoeroides sp.	9
				Unknown	52
7/13	IV-A	505	335	Bothidae - Bothus ocellatus	72
				Bothidae - Syacium sp.	359
				Bothidae - Syacium gunteri	144
				Engraulidae	383
				Microdesmidae - Microdesmus sp.	48
				Scombridae	24
				Scombridae - Scomberomorus cavalla	48
				Serranidae - Diplectrum sp.	24
				Serranidae - Serraniculus pumilio	24
				Unknown	48
7/13	IV-A	333	487	Bothidae - Bothus ocellatus	23
				Bothidae - Syacium sp.	464
				Bothidae - Syacium gunteri	116
				Clupeidae	162
				Cynoglossidae - Symphurus sp.	23
				Engraulidae	1,694
				Engraulidae - Anchoa sp.	464

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/13	IV-A	333		Gobiidae	162
				Lutjanidae	47
				Lutjanidae - *Lutjanus campechanus*	47
				Microdesmidae - *Microdesmus* sp.	23
				Sciaenidae - *Cynoscion* sp.	23
				Scombridae - *Euthynnus alletteratus*	23
				Scombridae - *Scomberomorus cavalla*	70
				Tetraodontidae	23
				Unknown	394
7/13	IV-B	505	24	Bothidae	143
				Bothidae - *Bothus* sp.	24
				Bothidae - *Bothus ocellatus*	167
				Bothidae - *Syacium* sp.	476
				Bothidae - *Syacium gunteri*	143
				Carangidae	71
				Clupeidae	71
				Clupeidae - *Harengula jaguana*	191
				Cynoglossidae - *Symphurus* sp.	71
				Engraulidac	1,357
				Engraulidae - *Anchoa* sp.	143
				Engraulidae - *Engraulis eurystole*	24
				Gobiidae	357
				Lutjanidae	24
				Lutjanidae - *Lutjanus campechanus*	48
				Microdesmidae - *Microdesmus* sp.	24
				Ophidiidae	24
				Sciaenidae	24
				Sciaenidae - *Cynoscion nothus*	71
				Scombridae - *Euthynnus alletteratus*	24

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/13	IV-B	505		Scombridae - *Scomberomorus cavalla*	238
				Scombridae - *Scomberomorus maculatus*	24
				Serranidae - *Diplectrum* sp.	191
				Serranidae - *Serraniculus pumilio*	95
				Tetraodontidae	24
				Triglidae - *Prionotus* sp.	24
				Unknown	119
7/13	IV-B	333	1,475	Bothidae	46
				Bothidae - *Bothus ocellatus*	230
				Bothidae - *Syacium* sp.	415
				Bothidae - *Syacium gunteri*	138
				Carangidae	23
				Carangidae - *Decapterus punctatus*	23
				Clupeidae	92
				Clupeidae - *Harengula jaguana*	115
				Cynoglossidae - *Symphurus* sp.	115
				Engraulidae	2,811
				Engraulidae - *Anchoa* sp.	461
				Gobiidae	230
				Lutjanidae	23
				Lutjanidae - *Lutjanus campechanus*	69
				Microdesmidae - *Microdesmus* sp.	46
				Ophidiidae	69
				Sciaenidae - *Cynoscion* sp.	115
				Scombridae - *Scomberomorus cavalla*	46
				Scombridae - *Scomberomorus maculatus*	23
				Serranidae	23
				Serranidae - *Diplectrum* sp.	207
				Serranidae - *Serraniculus pumilio*	69
				Tetraodontidae - *Sphoeroides* sp.	23

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/13	IV-B	333		Unknown	830
7/13	IV-C	505	354	Bothidae	24
				Bothidae - *Bothus ocellatus*	165
				Bothidae - *Syacium* sp.	377
				Bothidae - *Syacium gunteri*	24
				Carangidae	24
				Clupeidae	189
				Clupeidae - *Harengula jaguana*	212
				Cynoglossidae - *Symphurus* sp.	47
				Engraulidae	2,146
				Engraulidae - *Anchoa* sp.	1,132
				Gobiidae	212
				Grammistidae - *Rypticus* sp.	24
				Lutjanidae - *Lutjanus campechanus*	24
				Microdesmidae - *Microdesmus* sp.	47
				Sciaenidae	24
				Sciaenidae - *Cynoscion nothus*	118
				Scombridae - *Euthynnus alletteratus*	24
				Scombridae - *Scomberomorus cavalla*	47
				Serranidae - *Diplectrum* sp.	24
				Unknown	377
7/13	IV-C	333	2,717	Bothidae	46
				Bothidae - *Bothus ocellatus*	46
				Bothidae - *Cyclopsetta* sp.	46
				Bothidae - *Syacium* sp.	548
				Bothidae - *Syacium gunteri*	23
				Carangidae	91
				Clupeidae	388

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number Larvae per 1,000 m^3
7/13	IV-C	333		Clupeidae - Harengula jaguana	228
				Engraulidae	2,808
				Engraulidae - Anchoa sp.	936
				Gerreidae	23
				Gobiidae	297
				Lutjanidae	23
				Lutjanidae - Lutjanus campechanus	46
				Microdesmidae - Microdesmus sp.	23
				Muraenidae - Gymnothorax sp.	23
				Ophichthidae - Myrophis sp.	23
				Ophidiidae	23
				Sciaenidae - Cynoscion sp.	23
				Scombridae	23
				Scombridae - Euthynnus alletteratus	46
				Scombridae - Scomberomorus cavalla	23
				Serranidae - Diplectrum sp.	23
				Serranidae - Serraniculus pumilio	46
				Unknown	1,073
7/13	IV-D	505	14,613	Bothidae	28
				Bothidae - Bothus ocellatus	276
				Bothidae - Syacium sp.	470
				Bothidae - Syacium gunteri	138
				Clupeidae	138
				Clupeidae - Harengula jaguana	111
				Cynoglossidae - Symphurus sp.	83
				Engraulidae	1,989
				Engraulidae - Anchoa sp.	635
				Exocoetidae - Cypselurus sp.	28
				Gobiidae	304
				Lutjanidae - Lutjanus campechanus	83

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/13	IV-D	505		Microdesmidae - *Microdesmus* sp.	28
				Muraenidae	28
				Sciaenidae - *Cynoscion* sp.	28
				Sciaenidae - *Menticirrhus* sp.	28
				Scombridae - *Scomberomorus cavalla*	28
				Scorpaenidae - *Scorpaena* sp.	28
				Serranidae - *Diplectrum* sp.	166
				Serranidae - *Serraniculus pumilio*	83
				Tetraodontidae - *Sphoeroides* sp.	28
				Unknown	28
7/13	IV-D	333	18,702	Blenniidae	76
				Bothidae	25
				Bothidae - *Bothus ocellatus*	204
				Bothidae - *Syacium* sp.	356
				Bothidae - *Syacium gunteri*	25
				Carangidae	153
				Clupeidae	229
				Clupeidae - *Harengula jaguana*	51
				Cynoglossidae - *Symphurus* sp.	102
				Engraulidae	2,468
				Engraulidae - *Anchoa* sp.	1,069
				Gobiidae	204
				Lutjanidae - *Lutjanus campechanus*	25
				Microdesmidae - *Microdesmus* sp.	153
				Ogcocephalidae	25
				Ophidiidae	204
				Sciaenidae - *Cynoscion* sp.	102
				Sciaenidae - *Cynoscion nothus*	25
				Sciaenidae - *Menticirrhus* sp.	25

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/13	IV-D	333		Scombridae	25
				Scombridae - *Scomberomorus cavalla*	102
				Scorpaenidae - *Scorpaena* sp.	25
				Serranidae - *Diplectrum* sp.	153
				Serranidae - *Serraniculus pumilio*	51
				Synodontidae - *Synodus foetens*	25
				Unknown	280
7/14	V-A	505	28	Bothidae	38
				Bothidae - *Bothus ocellatus*	38
				Bothidae - *Cyclopsetta fimbriata*	10
				Bothidae - *Syacium* sp.	38
				Bothidae - *Syacium gunteri*	28
				Clupeidae	19
				Engraulidae	199
				Gobiidae	10
				Lutjanidae	19
				Lutjanidae - *Lutjanus campechanus*	10
				Microdesmidae - *Microdesmus* sp.	10
				Rachycentridae - *Rachycentron canadum*	10
				Sciaenidae - *Cynoscion* sp.	10
				Scombridae - *Euthynnus alletteratus*	10
				Serranidae	19
				Serranidae - *Diplectrum* sp.	10
				Serranidae - *Serraniculus pumilio*	10
				Unknown	10
7/14	V-A	333	275	Bothidae - *Bothus ocellatus*	37
				Bothidae - *Syacium gunteri*	28
				Carangidae	9
				Carangidae - *Chloroscombrus chrysurus*	9
				Clupeidae	55

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	V-A	333		Engraulidae	174
				Engraulidae - *Anchoa* sp.	9
				Engraulidae - *Engraulis eurystole*	46
				Gerreidae - *Eucinostomus* sp.	9
				Gobiidae	37
				Lutjanidae	9
				Lutjanidae - *Lutjanus campechanus*	18
				Microdesmidae - *Microdesmus* sp.	46
				Sciaenidae - *Menticirrhus* sp.	9
				Scombridae - *Euthynnus alletteratus*	9
				Unknown	64
7/14	V-B	505	70	Bothidae	35
				Bothidae - *Bothus ocellatus*	176
				Bothidae - *Syacium* sp.	70
				Bothidae - *Syacium gunteri*	106
				Carangidae - *Caranx* sp.	35
				Clupeidae - *Harengula jaguana*	70
				Cynoglossidae - *Symphurus* sp.	35
				Engraulidae	704
				Gobiidae	141
				Lutjanidae	70
				Lutjanidae - *Lutjanus campechanus*	70
				Muraenidae - *Gymnothorax* sp.	35
				Ophichthidae	35
				Sciaenidae - *Cynoscion nothus*	70
				Scombridae - *Euthynnus alletteratus*	106
				Serranidae - *Diplectrum* sp.	70
				Synodontidae - *Synodus* sp.	35
				Unknown	70

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	V-B	333	1,312	Bothidae	27
				Bothidae - *Bothus* sp.	27
				Bothidae - *Bothus ocellatus*	55
				Bothidae - *Syacium* sp.	82
				Bothidae - *Syacium gunteri*	191
				Clupeidae	355
				Clupeidae - *Harengula jaguana*	27
				Cynoglossidae - *Symphurus* sp.	27
				Engraulidae	874
				Engraulidae - *Anchoa* sp.	191
				Gobiidae	164
				Lutjanidae	27
				Lutjanidae - *Lutjanus campechanus*	82
				Microdesmidae - *Microdesmus* sp.	55
				Ogcocephalidae	82
				Ophichthidae - *Myrophis* sp.	27
				Ophidiidae	55
				Sciaenidae - *Cynoscion nothus*	27
				Scombridae - *Euthynnus alletteratus*	27
				Scombridae - *Scomberomorus cavalla*	27
				Serranidae	27
				Unknown	191
7/14	V-C	505	344	Bothidae	49
				Bothidae - *Bothus ocellatus*	123
				Bothidae - *Syacium* sp.	246
				Bothidae - *Syacium gunteri*	197
				Clupeidae - *Harengula jaguana*	98
				Cynoglossidae - *Symphurus* sp.	25
				Engraulidae	1,057
				Engraulidae - *Anchoa* sp.	74

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	V-C	505		Gerreidae	25
				Gobiidae	98
				Lutjanidae	74
				Ogcocephalidae	25
				Priacanthidae	25
				Sciaenidae - *Cynoscion nothus*	123
				Scombridae - *Euthynnus alletteratus*	25
				Synodontidae	25
				Unknown	295
7/14	V-C	333	21,674	Bothidae	70
				Bothidae - *Bothus ocellatus*	93
				Bothidae - *Cyclopsetta* sp.	23
				Bothidae - *Syacium* sp.	279
				Bothidae - *Syacium gunteri*	116
				Carangidae	23
				Carangidae - *Chloroscombrus chrysurus*	23
				Clupeidae	140
				Clupeidae - *Harengula jaguana*	23
				Cynoglossidae - *Symphurus* sp.	70
				Engraulidae	1,093
				Engraulidae - *Anchoa* sp.	372
				Gobiidae	186
				Lutjanidae	93
				Lutjanidae - *Lutjanus campechanus*	46
				Microdesmidae - *Microdesmus* sp.	47
				Muraenidae - *Gymnothorax* sp.	23
				Ogcocephalidae	23
				Sciaenidae - *Menticirrhus* sp.	23
				Scombridae - *Euthynnus alletteratus*	93
				Unknown	70

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	V-D	505	244	Bothidae	61
				Bothidae - Bothus ocellatus	183
				Bothidae - Syacium sp.	305
				Bothidae - Syacium gunteri	61
				Carangidae	31
				Clupeidae	122
				Clupeidae - Harengula jaguana	61
				Cynoglossidae - Symphurus sp.	31
				Engraulidae	884
				Engraulidae - Anchoa sp.	31
				Grammistidae - Rypticus sp.	31
				Lutjanidae	31
				Lutjanidae - Lutjanus campechanus	91
				Microdesmidae - Microdesmus sp.	31
				Sciaenidae - Cynoscion sp.	31
				Scombridae - Scomberomorus maculatus	31
				Serranidae - Serraniculus pumilio	31
				Unknown	31
7/14	V-D	333	1,535	Bothidae	51
				Bothidae - Bothus ocellatus	128
				Bothidae - Syacium sp.	102
				Bothidae - Syacium gunteri	26
				Carangidae	26
				Carangidae - Chloroscombrus chrysurus	51
				Clupeidae	128
				Clupeidae - Harengula jaguana	26
				Clupeidae - Opisthonema oglinum	77
				Cynoglossidae - Symphurus sp.	26
				Engraulidae	588

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
7/14	V-D	333		Engraulidae - Anchoa sp.	128
				Gobiidae	77
				Grammistidae - Rypticus sp.	26
				Lutjanidae	51
				Lutjanidae - Lutjanus campechanus	77
				Microdesmidae - Microdesmus sp.	51
				Ogcocephalidae	51
				Scombridae - Euthynnus alletteratus	26
				Serranidae - Diplectrum sp.	26
				Unknown	128
7/14	VI	505	1,713	Bothidae - Bothus sp.	31
				Bothidae - Syacium sp.	156
				Bothidae - Syacium gunteri	31
				Lutjanidae - Etelis oculatus	31
				Muraenidae	31
				Scombridae - Scomberomorus cavalla	31
				Serranidae - Diplectrum sp.	62
				Unknown	125
7/14 bo	VI	333	4,511	Bothidae - Syacium sp.	163
				Bothidae - Syacium gunteri	54
				Carangidae	27
				Clupeidae	82
				Cynoglossidae - Symphurus sp.	54
				Engraulidae	1,087
				Gerreidae - Eucinostomus sp.	27
				Microdesmidae - Microdesmus sp.	109
				Scombridae	54
				Scombridae - Euthynnus alletteratus	27
				Serranidae - Diplectrum sp.	109
				Unknown	571

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/13	I	505	1,133	Bothidae	67
				Engraulidae	400
				Engraulidae - *Anchoa* sp.	167
				Gobiidae	33
				Sciaenidae - *Cynoscion* sp.	333
				Sciaenidae - *Larimus fasciatus*	33
				Sciaenidae - *Menticirrhus* sp.	33
				Sciaenidae - *Micropogon undulatus*	367
10/13	I	333	890	Bothidae	92
				Engraulidae	307
				Engraulidae - *Anchoa* sp.	61
				Gobiidae	92
				Sciaenidae	153
				Sciaenidae - *Cynoscion* sp.	123
				Sciaenidae - *Micropogon undulatus*	184
				Unknown	31
10/13	II-A	505	0	Bothidae	101
				Engraulidae	503
				Engraulidae - *Anchoa* sp.	101
				Sciaenidae - *Cynoscion* sp.	905
				Sciaenidae - *Menticirrhus* sp.	50
				Sciaenidae - *Micropogon undulatus*	50
				Unknown	101
10/13	II-A	333	47	Blenniidae	283
				Bothidae	47
				Engraulidae	943

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/13	II-A	333		Engraulidae - *Anchoa* sp.	613
				Gobiidae	566
				Ophidiidae - *Rissola marginata*	330
				Sciaenidae - *Cynoscion* sp.	1,557
				Sciaenidae - *Menticirrhus* sp.	94
				Sciaenidae - *Micropogon undulatus*	1,038
				Unknown	377
10/13	II-B	505	37	Bothidae	37
				Engraulidae	475
				Engraulidae - *Anchoa* sp.	110
				Sciaenidae - *Cynoscion* sp.	1,898
				Sciaenidae - *Micropogon undulatus*	475
				Unknown	37
10/13	II-B	333	68	Blenniidae	68
				Bothidae - *Syacium* sp.	68
				Engraulidae	541
				Engraulidae - *Anchoa* sp.	405
				Gobiidae	135
				Sciaenidae	34
				Sciaenidae - *Cynoscion* sp.	1,115
				Sciaenidae - *Micropogon undulatus*	405
				Unknown	68
10/13	II-C	505	498	Bothidae	38
				Engraulidae	153
				Engraulidae - *Anchoa* sp.	805
				Gobiidae	77

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/13	II-C	505		Ophichthidae - *Myrophis* sp.	38
				Sciaenidae - *Cynoscion* sp.	1,303
				Sciaenidae - *Micropogon undulatus*	422
				Unknown	38
10/13	II-C	333	177	Carangidae	35
				Engraulidae	565
				Engraulidae - *Anchoa* sp.	848
				Gobiidae	106
				Ophidiidae - *Rissola marginata*	71
				Sciaenidae - *Cynoscion* sp.	989
				Sciaenidae - *Cynoscion nothus*	71
				Sciaenidae - *Micropogon undulatus*	389
				Tetraodontidae - *Sphoeroides* sp.	35
				Unknown	35
10/13	II-D	505	180	Bothidae	36
				Engraulidae	360
				Engraulidae - *Anchoa* sp.	576
				Sciaenidae - *Cynoscion* sp.	1,763
				Sciaenidae - *Cynoscion nothus*	252
				Sciaenidae - *Micropogon undulatus*	324
				Stromateidae - *Peprilus alepidotus*	36
10/13	II-D	333	141	Bothidae - *Syacium* sp.	35
				Engraulidae	212
				Engraulidae - *Anchoa* sp.	459
				Gobiidae	106
				Sciaenidae - *Cynoscion* sp.	1,166

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/13	II-D	333		Sciaenidae - *Micropogon undulatus*	318
				Unknown	35
10/14	III-A	505	2,261	Bothidae	217
				Bothidae - *Syacium* sp.	130
				Carangidae	130
				Clupeidae	44
				Engraulidae	7,783
				Engraulidae - *Anchoa* sp.	4,044
				Gobiidae	261
				Ophichthidae	44
				Ophidiidae	44
				Ophidiidae - *Rissola marginata*	130
				Sciaenidae	130
				Sciaenidae - *Cynoscion* sp.	2,000
				Sciaenidae - *Micropogon undulatus*	3,696
				Uranoscopidae	44
				Unknown	1,087
10/14	III-A	333	757	Bothidae	40
				Bothidae - *Syacium* sp.	120
				Engraulidae	2,510
				Engraulidae - *Anchoa* sp.	956
				Gobiidae	837
				Ophidiidae	40
				Ophidiidae - *Rissola marginata*	239
				Sciaenidae - *Cynoscion* sp.	638
				Sciaenidae - *Micropogon undulatus*	518
				Unknown	159
					32
					32

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/14	III-B	505	259	Bothidae - Syacium sp.	32
				Carangidae	32
				Engraulidae	1,165
				Engraulidae - Anchoa sp.	1,456
				Gobiidae	259
				Sciaenidae - Cynoscion sp.	162
				Sciaenidae - Micropogon undulatus	777
				Unknown	194
10/14	III-B	333	460	Bothidae	42
				Bothidae - Syacium sp.	42
				Clupeidae	84
				Engraulidae	2,218
				Engraulidae - Anchoa sp.	1,506
				Gobiidae	167
				Ophidiidae	42
				Ophidiidae - Rissola marginata	126
				Sciaenidae - Cynoscion sp.	335
				Sciaenidae - Micropogon undulatus	670
				Unknown	167
10/14	III-C	505	621	Bothidae	35
				Bothidae - Syacium sp.	35
				Carangidae	103
				Carangidae - Chloroscombrus chrysurus	35
				Engraulidae	1,414
				Engraulidae - Anchoa sp.	793
				Gobiidae	172
				Ophichthidae	35
				Ophidiidae	35
				Ophidiidae - Rissola marginata	138

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/14	III-C	505		Sciaenidae - *Cynoscion* sp.	517
				Sciaenidae - *Micropogon undulatus*	1,103
				Unknown	103
10/14	III-C	333	584	Cynoglossidae - *Symphurus* sp.	33
				Engraulidae	844
				Engraulidae - *Anchoa* sp.	422
				Gobiidae	97
				Ophidiidae - *Rissola marginata*	33
				Sciaenidae - *Cynoscion* sp.	162
				Sciaenidae - *Cynoscion nothus*	33
				Sciaenidae - *Micropogon undulatus*	747
				Unknown	33
10/14	III-D	505	455	Bothidae	38
				Engraulidae	682
				Engraulidae - *Anchoa* sp.	909
				Gobiidae	189
				Ophidiidae	38
				Ophidiidae - *Rissola marginata*	38
				Sciaenidae	189
				Sciaenidae - *Cynoscion* sp.	568
				Sciaenidae - *Micropogon undulatus*	379
				Unknown	76
10/14	III-D	333	556	Bothidae	69
				Engraulidae	1,111
				Engraulidae - *Anchoa* sp.	903
				Gobiidae	313
				Sciaenidae - *Cynoscion* sp.	243

Table 29. (Continued)

Date (1977)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/14	III-D	333		Sciaenidae - *Micropogon undulatus*	521
				Unknown	35
10/14	IV-A	505	299	Engraulidae	389
				Engraulidae - *Anchoa* sp.	60
				Gobiidae	30
				Sciaenidae - *Cynoscion* sp.	180
				Sciaenidae - *Larimus fasciatus*	30
				Sciaenidae - *Micropogon undulatus*	270
				Unknown	60
10/14	IV-A	333	313	Bothidae	29
				Engraulidae	456
				Gobiidae	114
				Ophidiidae - *Rissola marginata*	342
				Sciaenidae - *Cynoscion* sp.	29
				Sciaenidae - *Micropogon undulatus*	256
				Unknown	29
10/14	IV-B	505	288	Engraulidae	383
				Ophidiidae - *Rissola marginata*	64
				Sciaenidae - *Cynoscion* sp.	351
				Sciaenidae - *Micropogon undulatus*	288
10/14	IV-B	333	92	Bothidae	92
				Bothidae - *Syacium gunteri*	31
				Carangidae	31
				Carangidae - *Chloroscombrus chrysurus*	31
				Engraulidae	523
				Sciaenidae - *Cynoscion* sp.	308

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/14	IV-B	333		Sciaenidae - *Micropogon undulatus*	277
				Unknown	31
10/14	IV-C	505	0	Bothidae	90
				Bothidae - *Syacium* sp.	45
				Engraulidae	315
				Engraulidae - *Anchoa* sp.	45
				Gobiidae	45
				Ophichthidae - *Myrophis* sp.	45
				Ophidiidae	45
				Sciaenidae - *Cynoscion* sp.	811
				Sciaenidae - *Micropogon undulatus*	496
10/14	IV-C	333	208	Cynoglossidae - *Symphurus* sp.	42
				Engraulidae	542
				Gobiidae	208
				Ophidiidae - *Rissola marginata*	250
				Sciaenidae - *Cynoscion* sp.	792
				Sciaenidae - *Larimus fasciatus*	42
				Sciaenidae - *Micropogon undulatus*	958
				Unknown	42
10/14	IV-D	505	71	Engraulidae	353
				Sciaenidae - *Cynoscion* sp.	283
				Sciaenidae - *Menticirrhus* sp.	35
				Sciaenidae - *Micropogon undulatus*	353
10/14	IV-D	333	138	Carangidae - *Chloroscombrus chrysurus*	69
				Engraulidae	346
				Engraulidae - *Anchoa* sp.	104

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/14	IV-D	333		Ophidiidae - *Rissola* *marginata*	35
				Sciaenidae - *Cynoscion* sp.	104
				Sciaenidae - *Micropogon* *undulatus*	1,038
				Unknown	35
10/14	V-A	505	357	Bothidae	33
				Carangidae - *Chloroscombrus* *chrysurus*	33
				Engraulidae	779
				Engraulidae - *Anchoa* sp.	33
				Sciaenidae - *Micropogon* *undulatus*	390
10/14	V-A	333	180	Blenniidae	30
				Bothidae	30
				Engraulidae	240
				Engraulidae - *Anchoa* sp.	60
				Gobiidae	30
				Ophichthidae	30
				Ophidiidae - *Rissola* *marginata*	30
				Sciaenidae - *Cynoscion* sp.	90
				Sciaenidae - *Micropogon* *undulatus*	240
				Triglidae - *Prionotus* sp.	30
				Unknown	60
10/14	V-B	505	110	Engraulidae	74
				Sciaenidae	37
				Sciaenidae - *Cynoscion* sp.	147
				Sciaenidae - *Micropogon* *undulatus*	147
10/14	V-B	333	208	Blenniidae	35
				Bothidae	35

Table 29. (Continued)

Date (1977)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/14	V-B	333		Engraulidae	35
				Engraulidae - *Anchoa* sp.	69
				Ophichthidae	35
				Sciaenidae - *Cynoscion* sp.	35
				Sciaenidae - *Cynoscion nothus*	35
				Sciaenidae - *Menticirrhus* sp.	35
				Sciaenidae - *Micropogon undulatus*	278
10/14	V-C	505	87	Carangidae - *Chloroscombrus chrysurus*	43
				Engraulidae	260
				Engraulidae - *Anchoa* sp.	43
				Sciaenidae - *Cynoscion* sp.	130
				Sciaenidae - *Micropogon undulatus*	87
10/14	V-C	333	230	Engraulidae	115
				Engraulidae - *Anchoa* sp.	115
				Gobiidae	77
				Ophidiidae	38
				Ophidiidae - *Rissola marginata*	153
				Sciaenidae - *Larimus fasciatus*	38
				Sciaenidae - *Micropogon undulatus*	383
				Unknown	77
10/14	V-D	505	39	Bothidae	77
				Engraulidae	232
				Gobiidae	39
				Sciaenidae - *Cynoscion* sp.	39
				Sciaenidae - *Micropogon undulatus*	193
10/14	V-D	333	142	Bothidae - *Syacium* sp.	106
				Bothidae - *Syacium gunteri*	36

Table 29. (Continued)

Date (1977)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
10/14	V-D	333		Carangidae - *Chloroscombrus chrysurus*	36
				Engraulidae	106
				Gobiidae	36
				Sciaenidae - *Cynoscion* sp.	71
				Sciaenidae - *Micropogon undulatus*	213
10/14	VI	505	244	Bothidae - *Syacium* sp.	31
				Carangidae - *Chloroscombrus chrysurus*	31
				Engraulidae	488
				Engraulidae - *Anchoa* sp.	183
				Gobiidae	31
				Ophichthidae - *Myrophis* sp.	81
				Ophidiidae	92
				Sciaenidae - *Cynoscion* sp.	92
				Unknown	31
10/14	VI	333	167	Bothidae - *Syacium* sp.	28
				Bothidae - *Syacium gunteri*	28
				Cynoglossidae - *Symphurus* sp.	56
				Engraulidae	279
				Engraulidae - *Anchoa* sp.	167
				Ophidiidae - *Rissola marginata*	84
				Sciaenidae - *Cynoscion* sp.	56
				Sciaenidae - *Micropogon undulatus*	84

Table 29. (Continued)

Date (1978)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/20	I	505	80	----	----
2/20	I	333	71	----	----
2/20	II-A	505	0	Stromateidae - Peprilus burti	44
2/20	II-A	333	0	Pomadasyidae Sparidae	48 48
2/20	II-B	505	0	----	----
2/20	II-B	333	0	Clupeidae Engraulidae Unknown	58 29 29
2/20	II-C	505	70	Clupeidae - Brevoortia sp. Stromateidae - Peprilus burti Unknown	209 35 35
2/20	II-C	333	290	Carangidae - Trachurus lathami Clupeidae - Brevoortia sp. Pomadasyidae	65 290 32
2/20	II-D	505	0	Clupeidae - Brevoortia sp.	13
2/20	II-D	333	25	Clupeidae - Brevoortia sp. Unknown	25 12

Table 29. (Continued)

Date (1978)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/22	III-A	505	132	Clupeidae - *Brevoortia patronus*	33
2/22	III-A	333	83	Clupeidae	276
				Pomadasyidae	28
				Sciaenidae	28
				Sparidae	83
				Triglidae - *Prionotus* sp.	55
2/22	III-B	505	132	Carangidae - *Trachurus lathami*	33
				Sparidae	33
2/22	III-B	333	89	Bothidae	29
				Clupeidae	384
				Pomadasyidae	88
				Stromateidae - *Peprilus burti*	59
				Unknown	29
2/22	III-C	505	194	Clupeidae - *Brevoortia* sp.	97
				Serranidae - *Centropristis* sp.	32
				Sparidae	32
				Stromateidae - *Peprilus burti*	65
2/22	III-C	333	59	Clupeidae	324
				Pomadasyidae	29
				Serranidae - *Centropristis* sp.	29
				Sparidae	147
				Unknown	29

Table 29. (Continued)

Date (1978)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/22	III-D	505	62	Carangidae - *Trachurus lathami*	31
				Clupeidae - *Brevoortia* sp.	62
				Stromateidae - *Peprilus burti*	31
2/22	III-D	333	168	Bothidae	28
				Clupeidae	642
				Ophidiidae - *Rissola marginata*	28
				Pomadasyidae	168
				Sparidae	84
				Sparidae - *Lagodon rhomboides*	28
				Stromateidae - *Peprilus burti*	28
				Unknown	56
2/20	IV-A	505	0	Bothidae - *Paralichthys* sp.	33
				Stromateidae - *Peprilus burti*	65
2/20	IV-A	333	0	Bothidae	30
				Carangidae - *Trachurus lathami*	30
				Clupeidae - *Brevoortia* sp.	30
				Serranidae - *Centropristis* sp.	61
				Stromateidae - *Peprilus burti*	30
2/22	IV-B	505	230	Carangidae - *Trachurus lathami*	33
				Clupeidae	33
				Serranidae	33
				Sparidae	33

Table 29. (continued)

Date (1978)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/22	IV-B	333	60	Clupeidae	179
				Pomadasyidae	30
				Serranidae - *Centropristis* sp.	30
				Stromateidae - *Peprilus burti*	30
				Unknown	30
2/22	IV-C	505	189	Carangidae - *Trachurus lathami*	31
				Clupeidae	94
				Serranidae - *Centropristis* sp.	31
				Sparidae	63
				Sparidae - *Lagodon rhomboides*	31
				Stromateidae - *Peprilus burti*	189
				Unknown	63
2/22	IV-C	333	122	Bothidae	61
				Carangidae - *Trachurus lathami*	92
				Clupeidae	398
				Pomadasyidae	61
				Serranidae - *Centropristis* sp.	31
				Sparidae	31
				Stromateidae - *Peprilus burti*	31
				Triglidae - *Prionotus* sp.	31
				Unknown	31
2/22	IV-D	505	322	Clupeidae	161
				Ophidiidae - *Rissola marginata*	32
				Serranidae - *Centropristis* sp.	32
				Sparidae	96
				Stromateidae - *Peprilus burti*	32

Table 29. (Continued)

Date (1978)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/22	IV-D	333	144	Bothidae	57
				Carangidae - *Trachurus lathami*	29
				Clupeidae	144
				Pomadasyidae	115
				Sparidae	29
				Stromateidae - *Peprilus burti*	29
2/22	V-A	505	37	Clupeidae	73
				Stromateidae - *Peprilus burti*	110
2/22	V-A	333	0	Clupeidae - *Brevoortia* sp.	169
				Pomadasyidae	136
				Sparidae	34
2/22	V-B	505	185	Carangidae - *Trachurus lathami*	37
				Clupeidae	111
				Pomadasyidae	37
				Serranidae - *Centropristis* sp.	37
				Stromateidae - *Peprilus burti*	37
				Unknown	37
2/22	V-B	333	135	Bothidae	34
				Clupeidae	202
				Sciaenidae	34
				Sparidae	34
				Unknown	67
2/22	V-C	505	29	Bregmacerotidae - *Bregmaceros atlanticus*	29

Table 29. (Continued)

Date (1978)	Station	Mesh size (μ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/22	V-C	505		Clupeidae	29
				Ophidiidae - *Rissola marginata*	29
2/22	V-C	333	183	Clupeidae	157
				Pomadasyidae	26
				Unknown	26
2/22	V-D	505	0	Clupeidae	171
				Sciaenidae - *Micropogon undulatus*	34
				Stromateidae - *Peprilus burti*	34
				Synodontidae - *Synodus foetens*	34
2/22	V-D	333	31	Bothidae - *Paralichthys* sp.	31
				Clupeidae	186
				Clupeidae - *Brevoortia* sp.	62
				Ophidiidae - *Rissola marginata*	62
				Pomadasyidae	62
				Sparidae	31
2/22	VI	505	204	Clupeidae	122
				Sciaenidae - *Micropogon undulatus*	41
				Triglidae - *Prionotus* sp.	41
2/22	VI	333	1,043	Bothidae	36
				Clupeidae	1,655
				Clupeidae - *Brevoortia* sp.	216
				Gadidae - *Urophycis* sp.	36
				Sciaenidae	72
				Serranidae	36

Table 29. (Continued)

Date (1978)	Station	Mesh size (µ)	Number eggs per 1,000 m^3	Larvae	Number larvae per 1,000 m^3
2/22	VI	333		Stromateidae - *Peprilus burti*	72
				Synodontidae - *Saurida* sp.	72
				Unknown	180

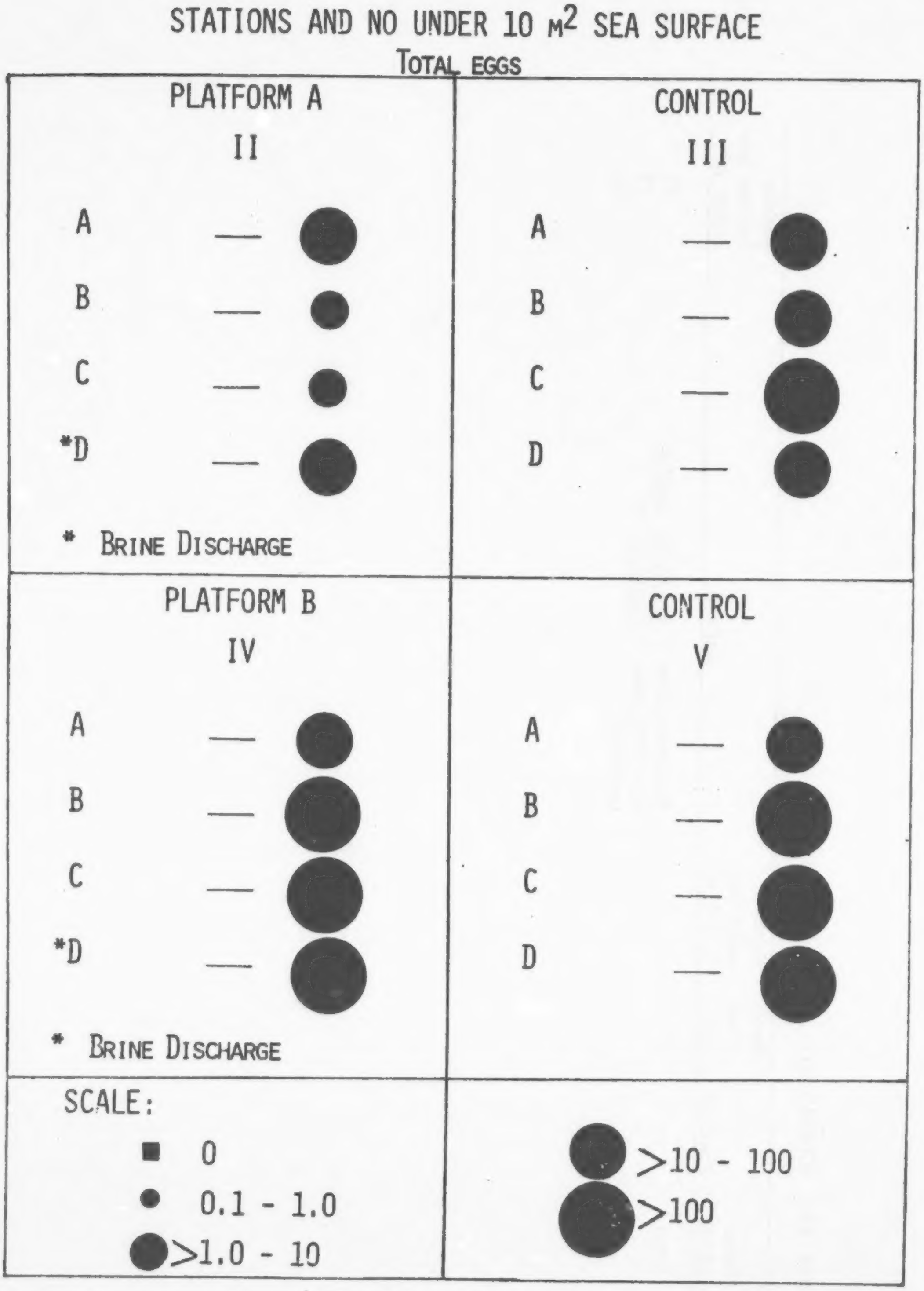


Figure 2 . Comparison of abundance and distribution of all fish eggs between platforms and control satellites for Cruise 1.

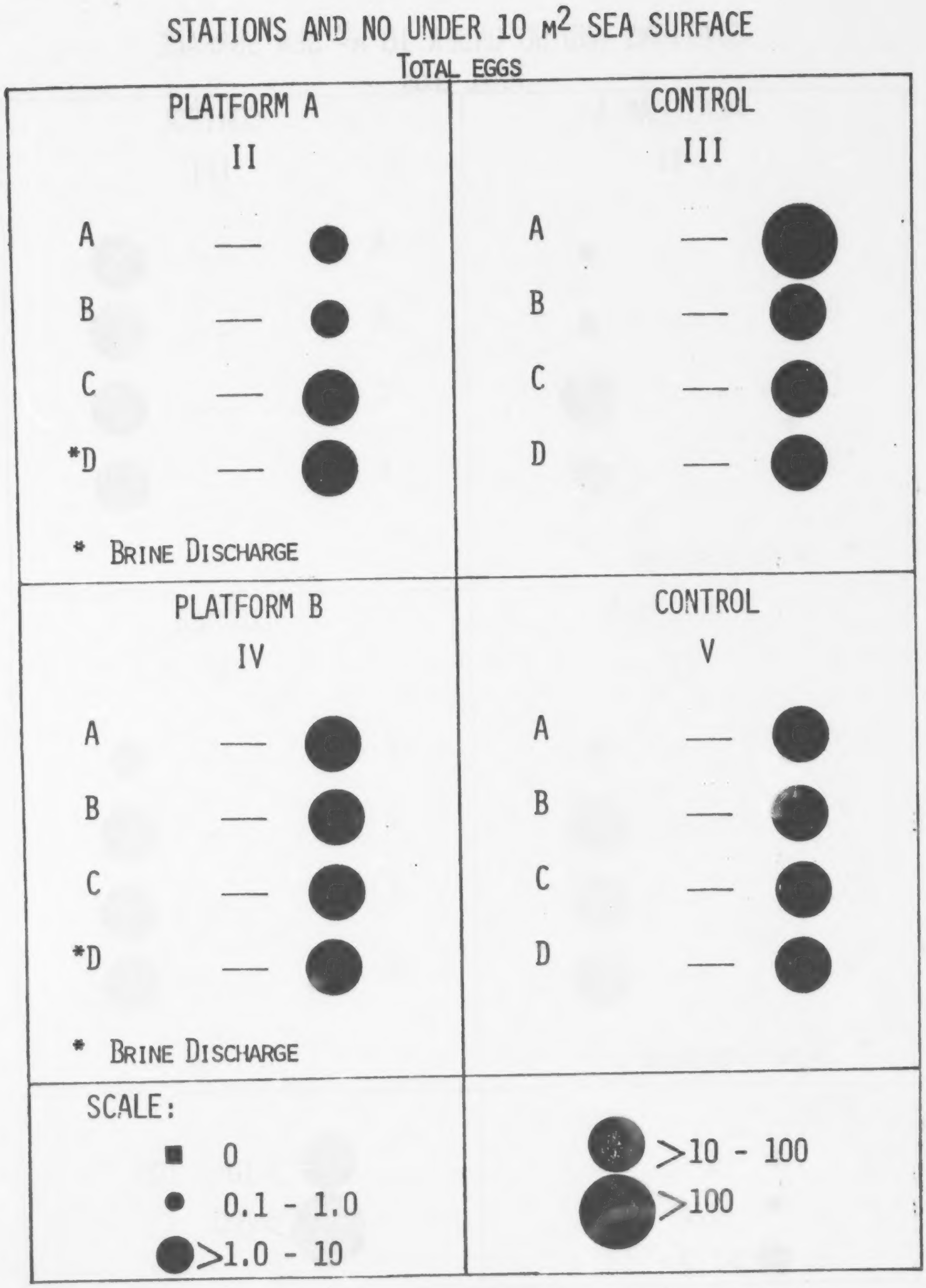


Figure 3. Comparison of abundance and distribution of all fish eggs between platforms and control satellites for Cruise 2.

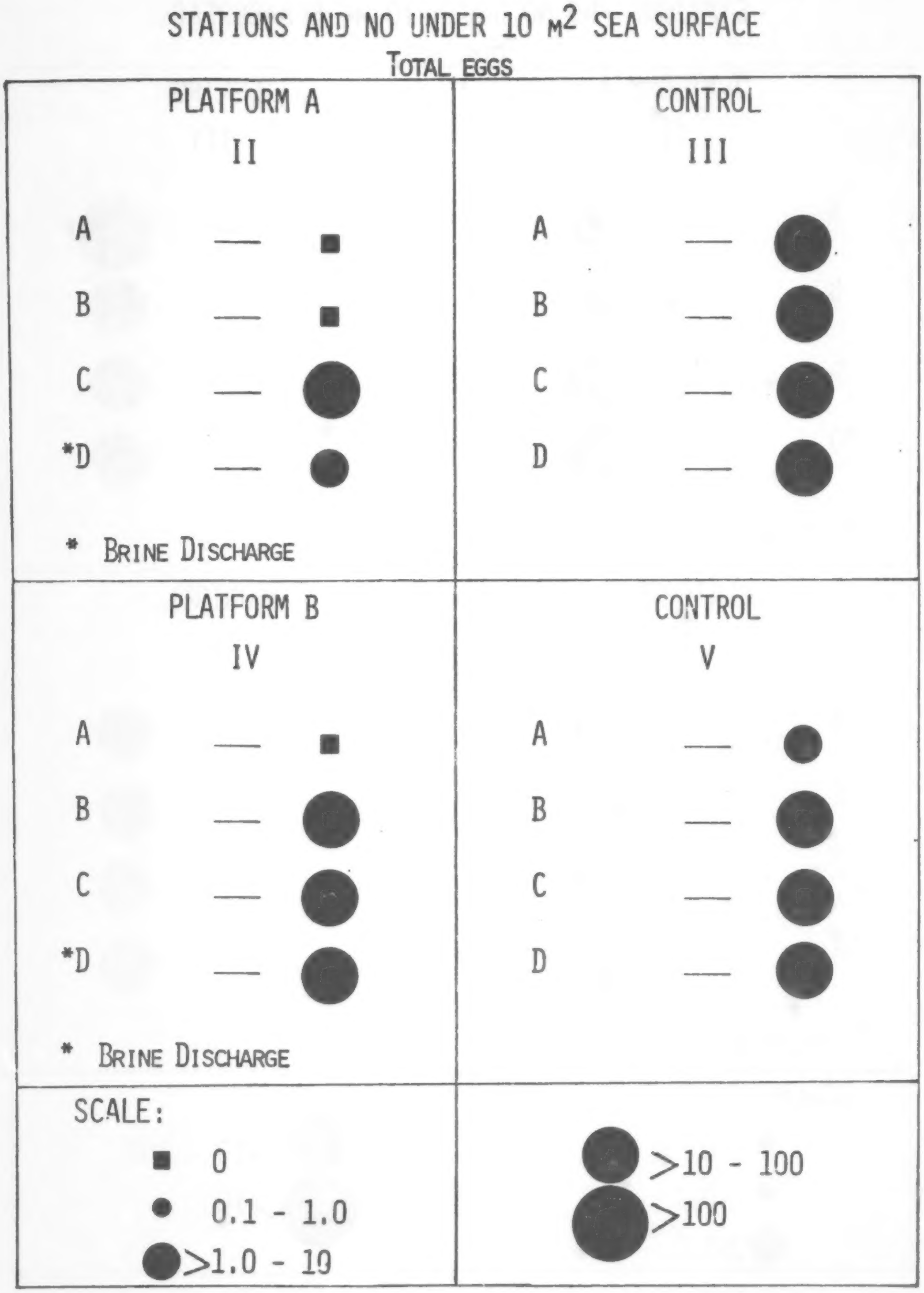


Figure 4 . Comparison of abundance and distribution of all fish eggs between platforms and control satellites for Cruise 3.

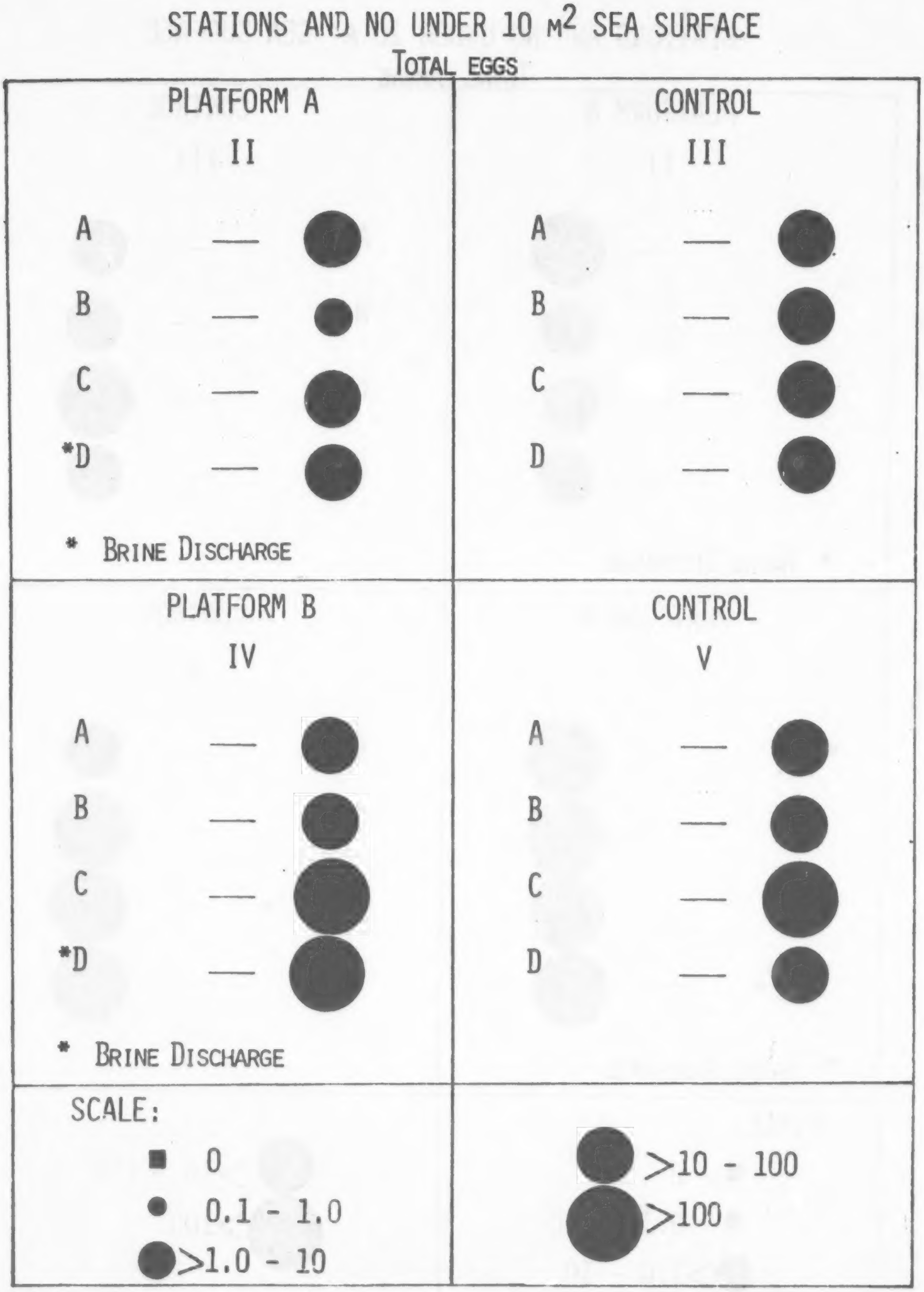


Figure 5 . Comparison of abundance and distribution of all fish eggs between platforms and control satellites for Cruises 1, 2, and 3.

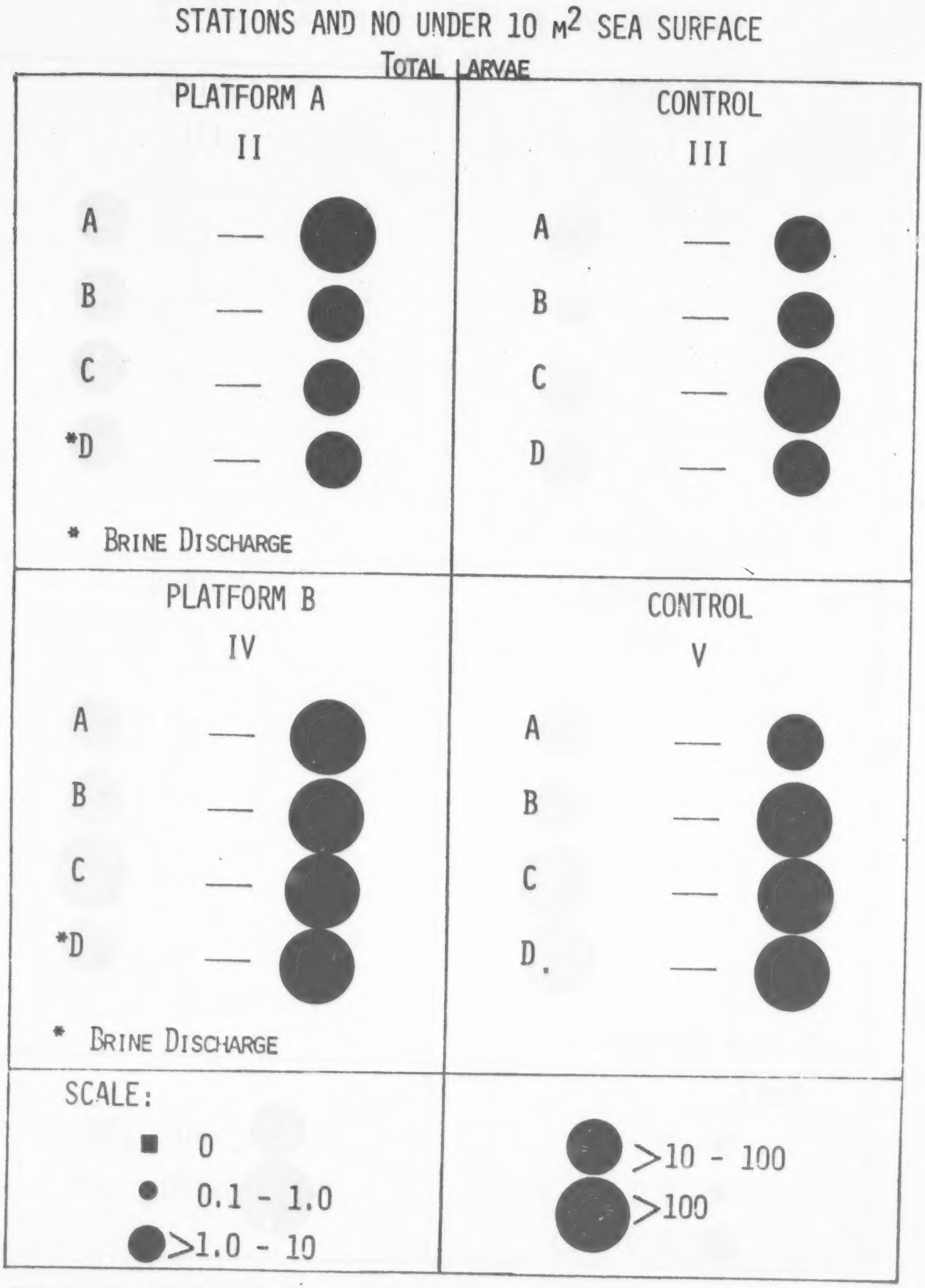


Figure 6. Comparison of abundance and distribution of all fish larvae between platforms and control satellites for Cruise 1.

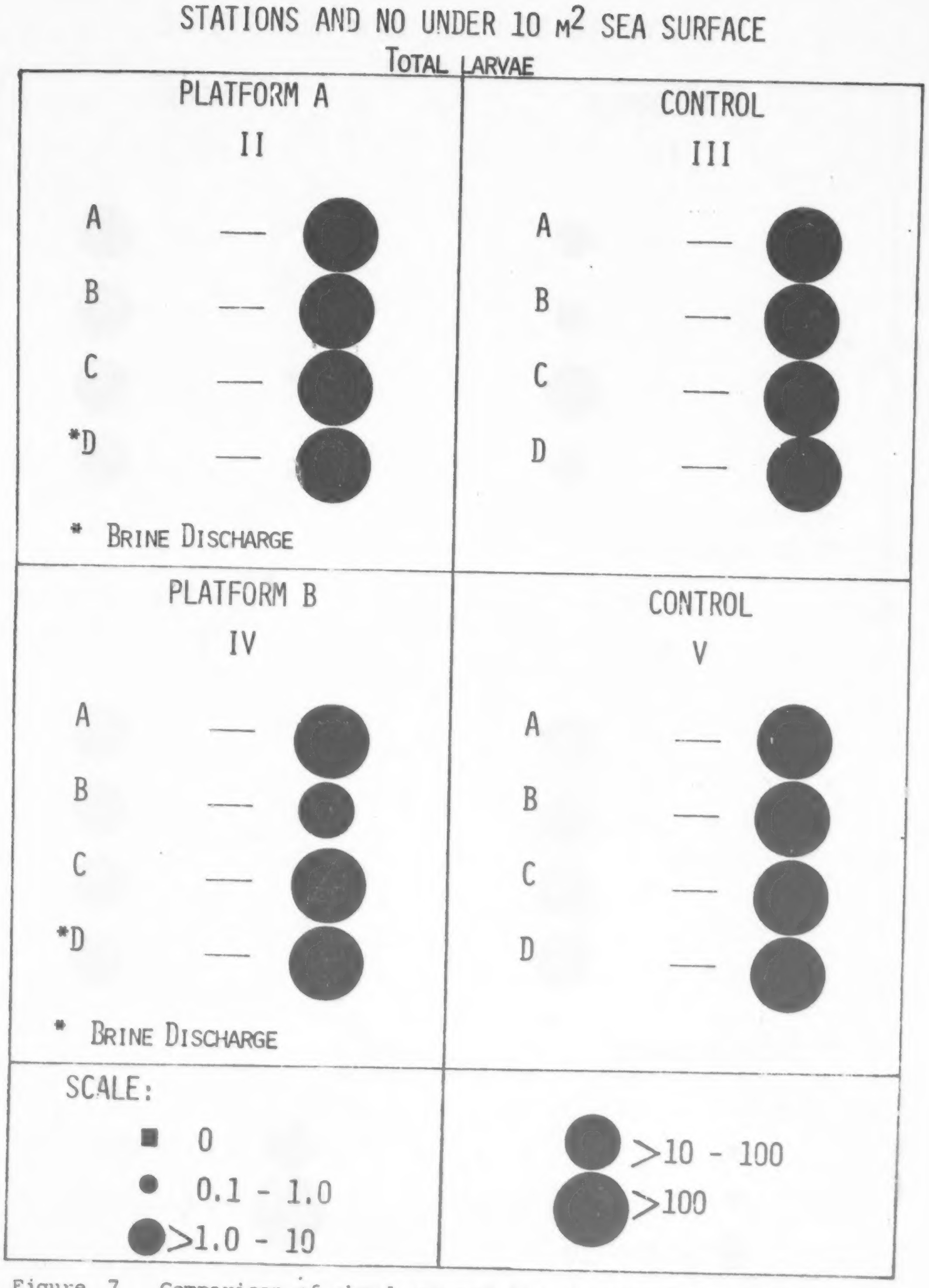


Figure 7. Comparison of abundance and distribution of all fish larvae between platforms and control satellites for Cruise 2.

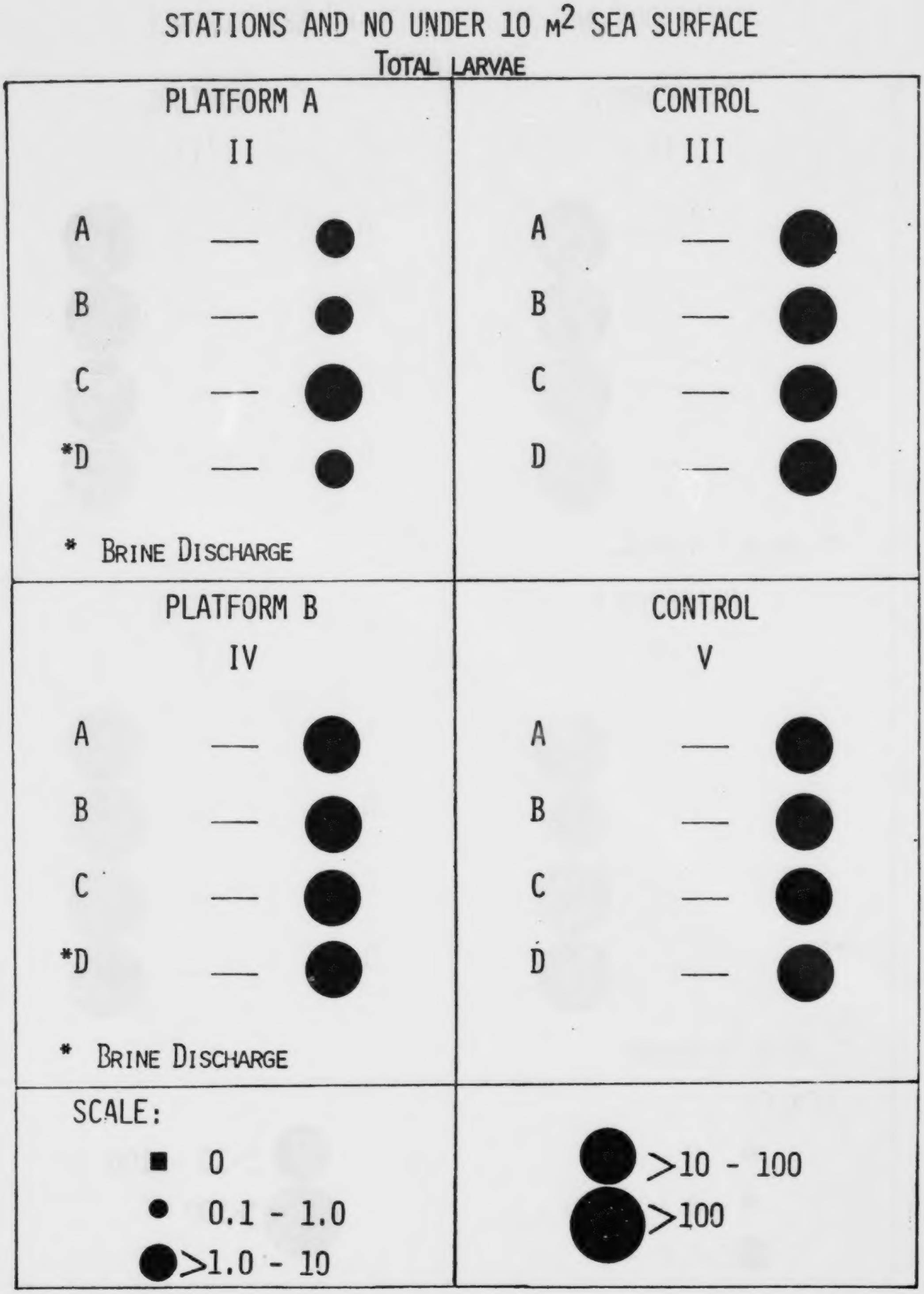


Figure 8 . Comparison of abundance and distribution of all fish larvae between platforms and control satellites for Cruise 3.

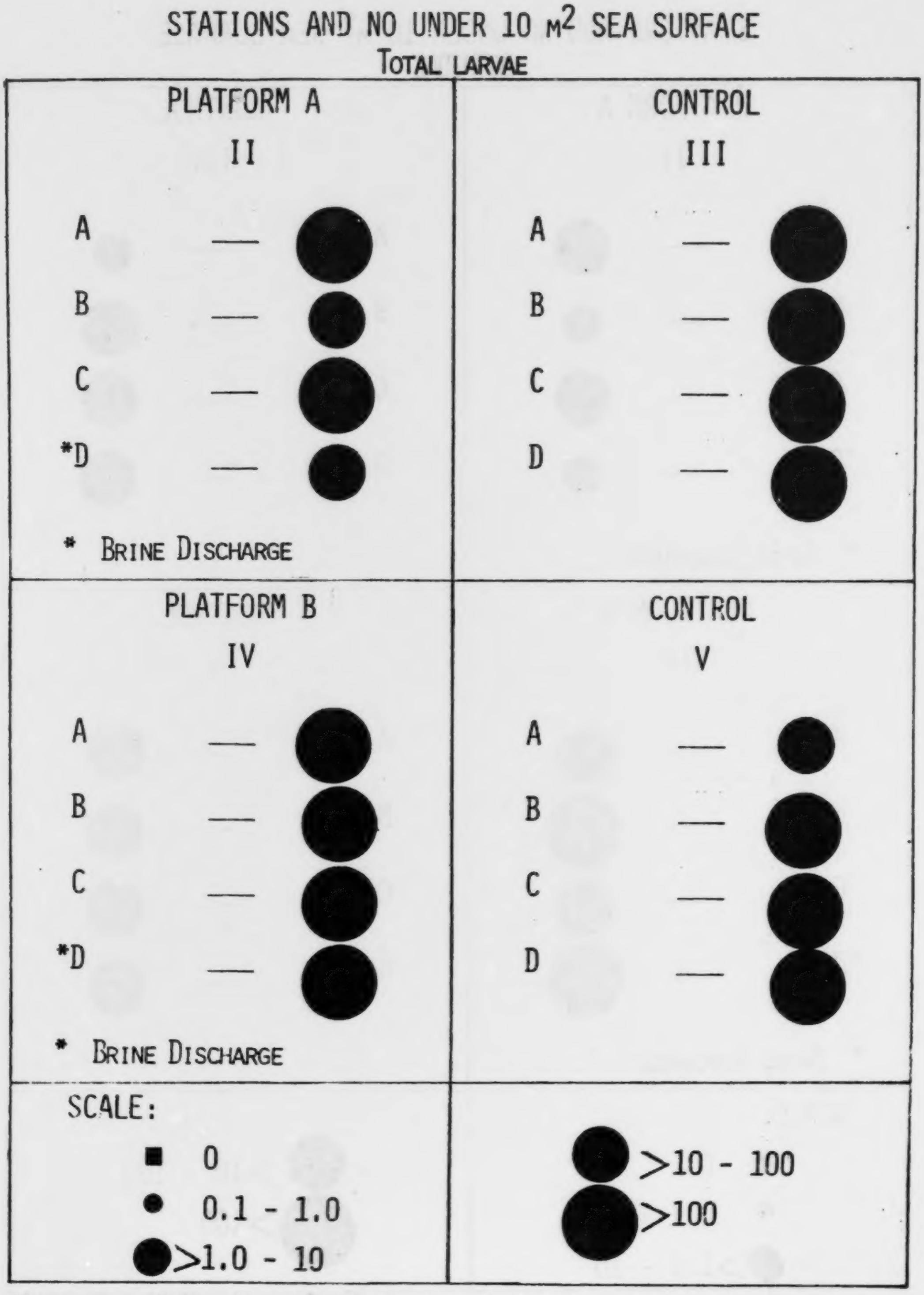


Figure 9 . Comparison of abundance and distribution of all fish larvae between platforms and control satellites for Cruises 1, 2, and 3.

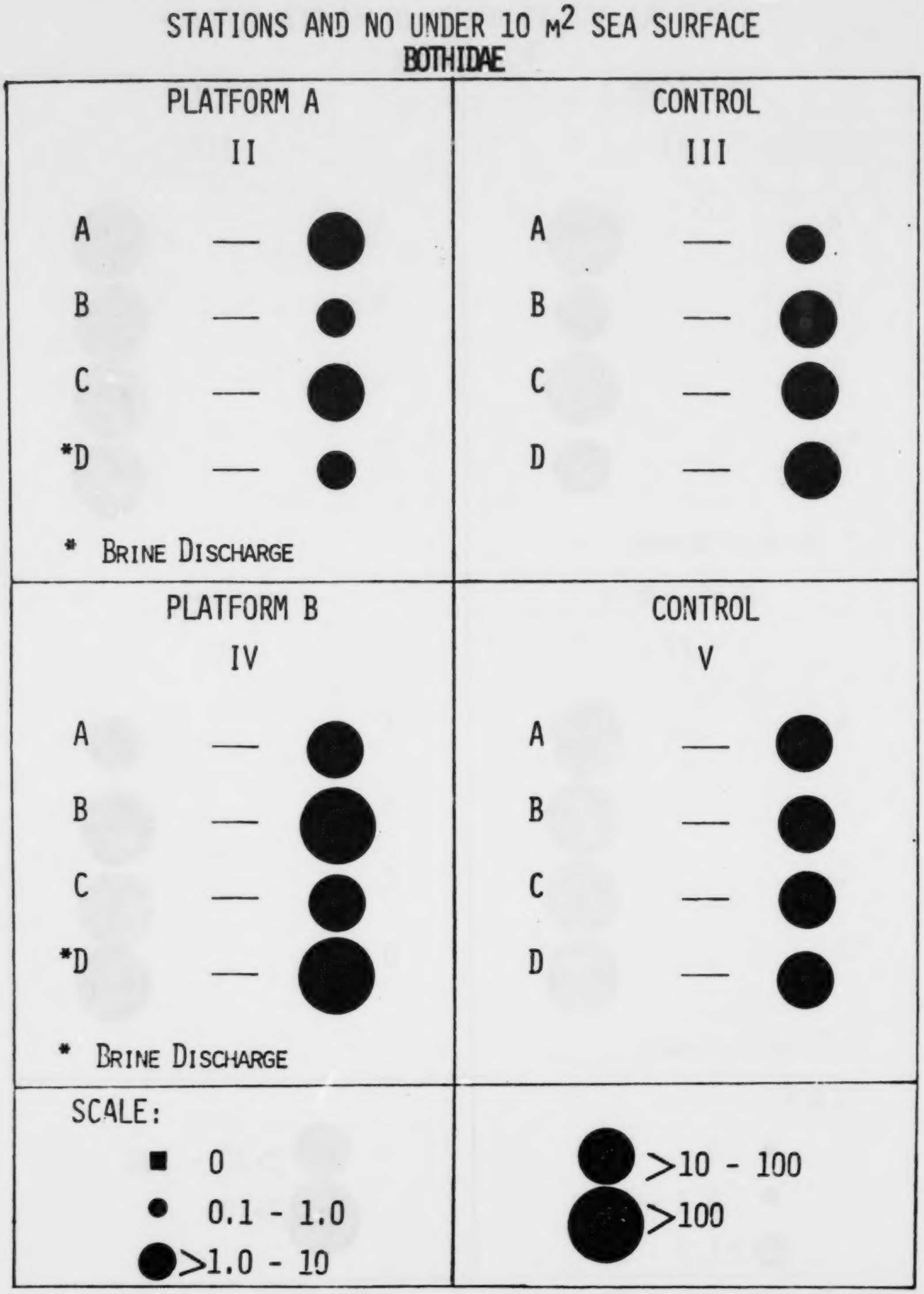


Figure 10. Comparison of abundance and distribution of Bothidae between platforms and control satellites for Cruise 1.

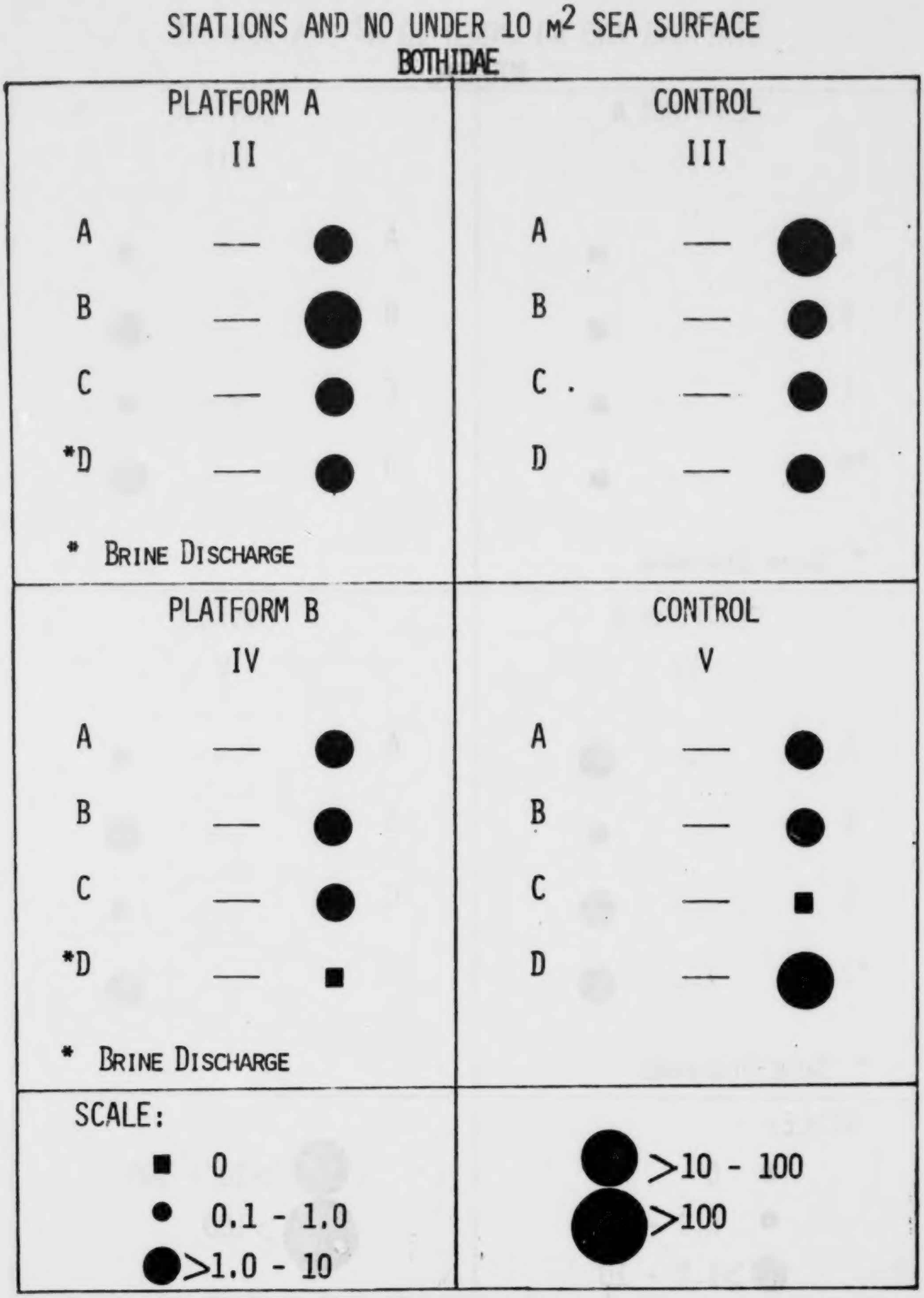


Figure 11. Comparison of abundance and distribution of Bothidae between platforms and control satellites for Cruise 2.

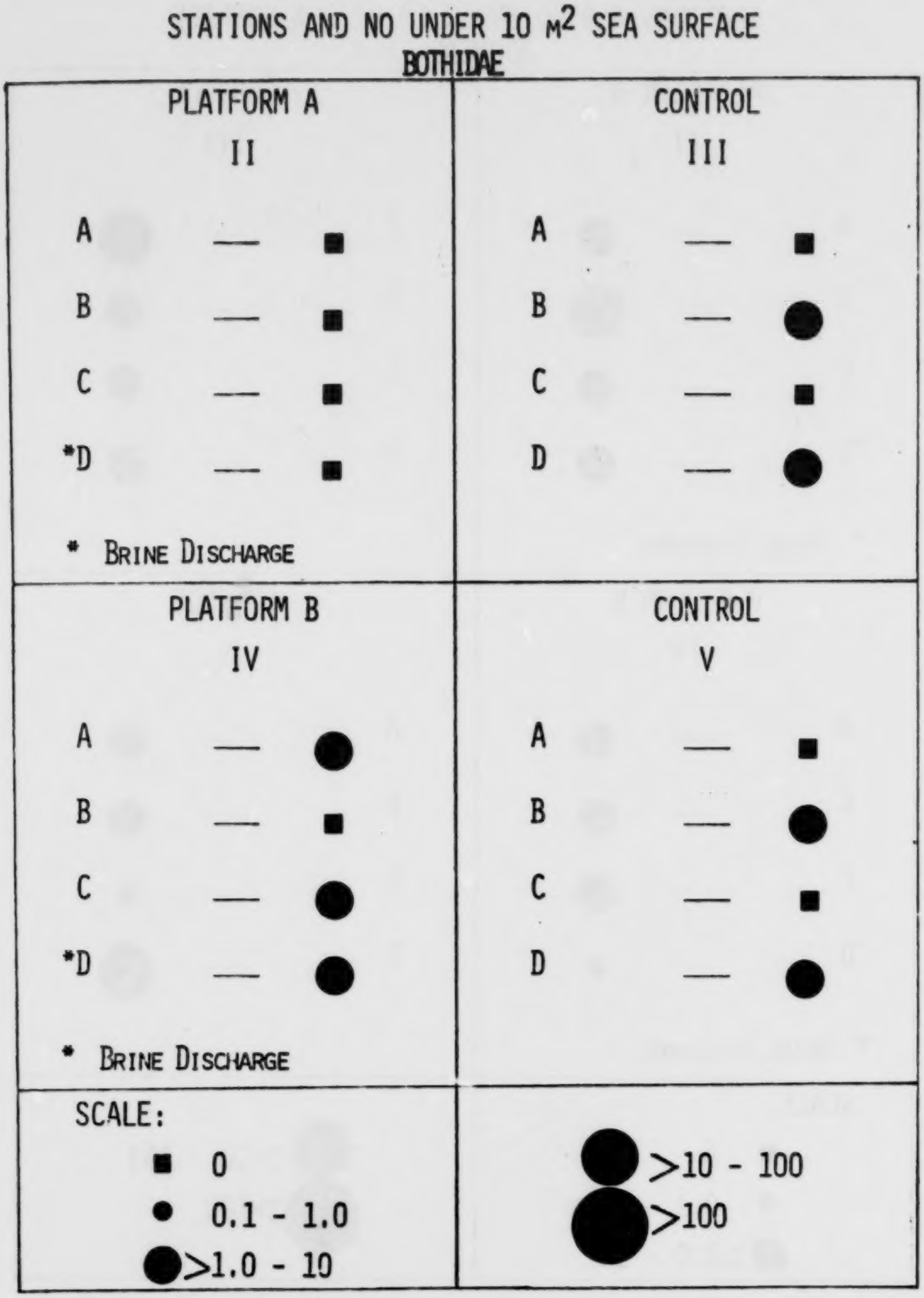


Figure 12. Comparison of abundance and distribution of Bothidae between platforms and control satellites for Cruise 3.

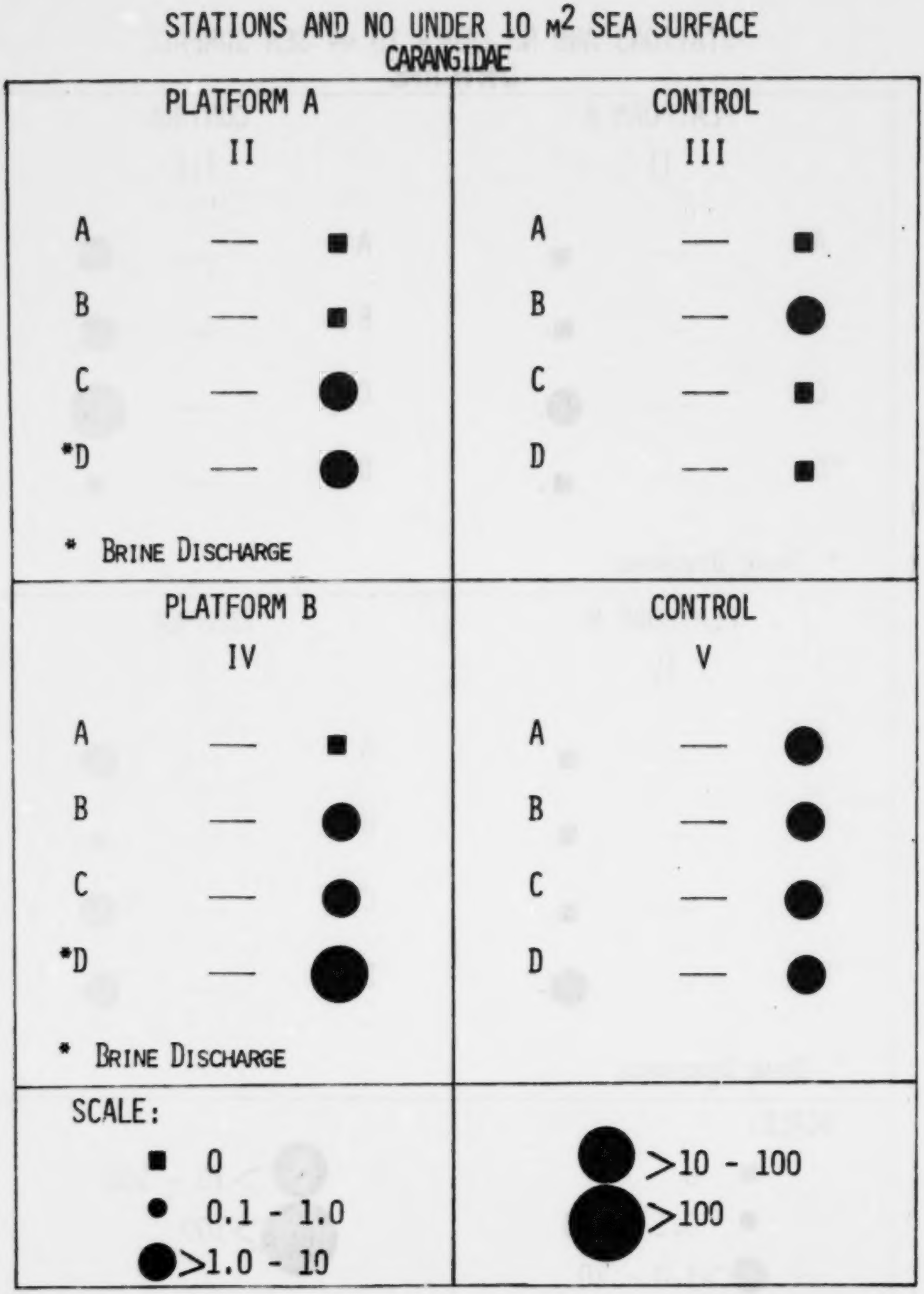


Figure 13. Comparison of abundance and distribution of Carangidae between platforms and control satellites for Cruise 1.

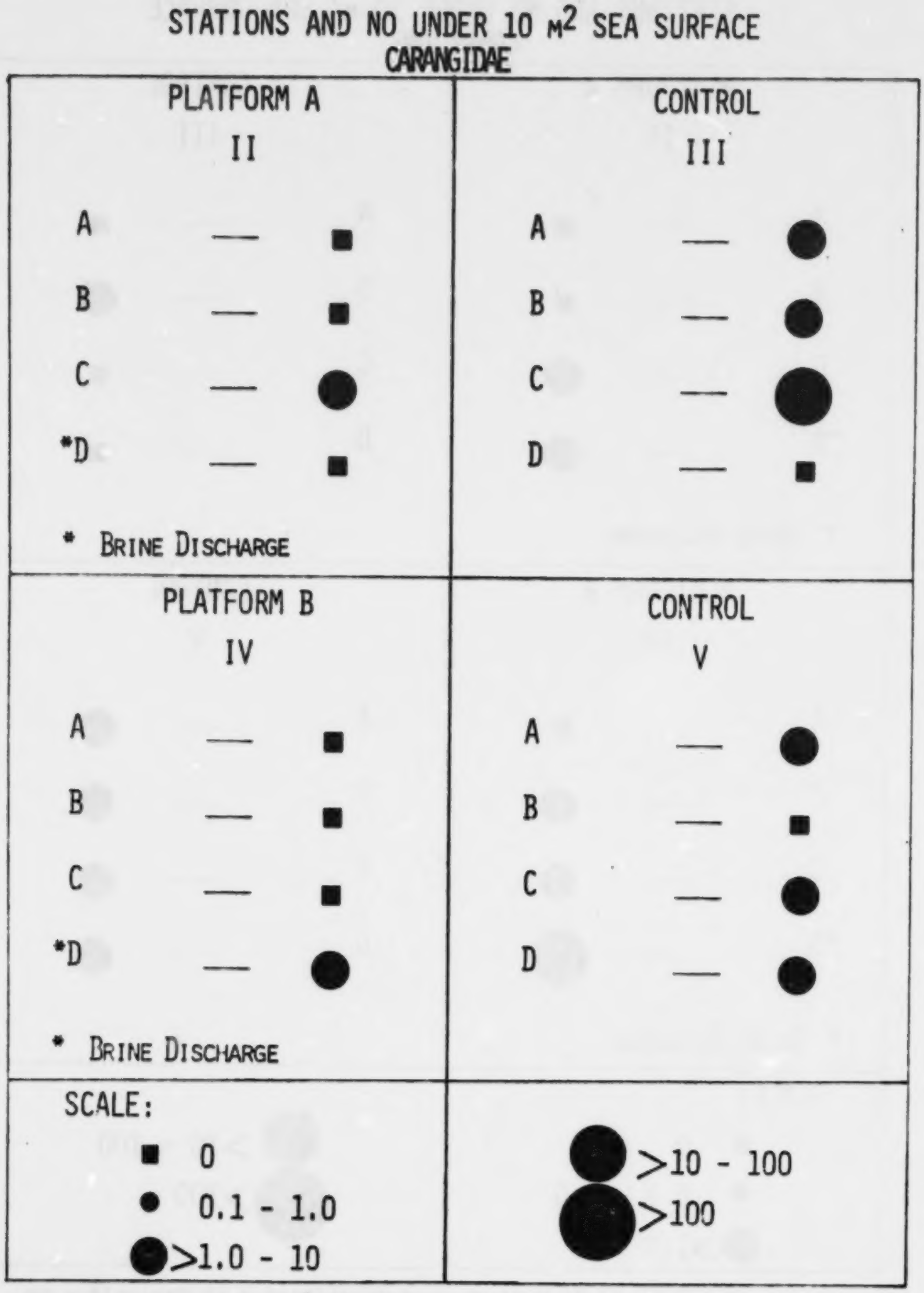


Figure 14. Comparison of abundance and distribution of Carangidae between platforms and control satellites for Cruise 2.

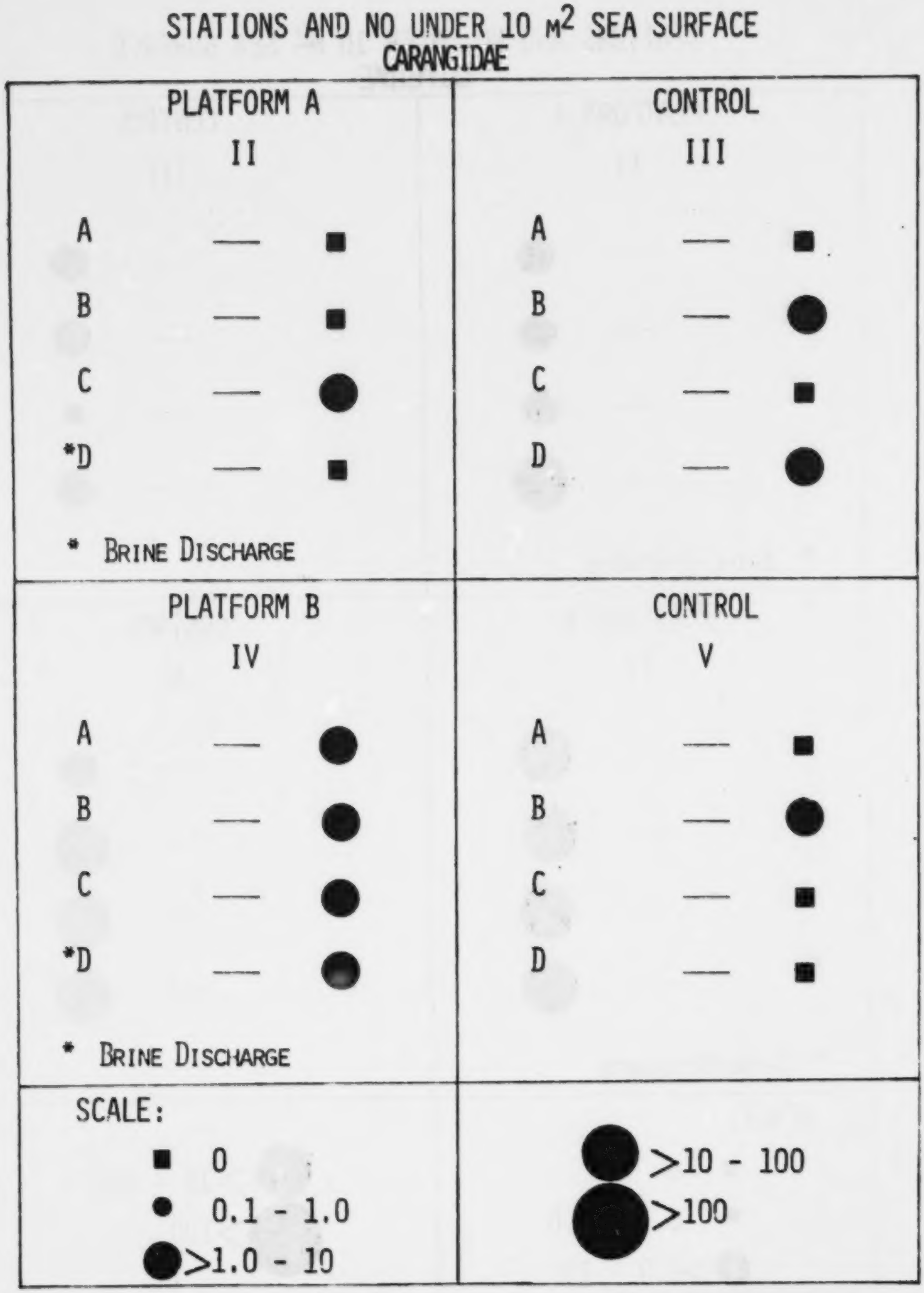


Figure 15. Comparison of abundance and distribution of Carangidae between platforms and control satellites for Cruise 3.

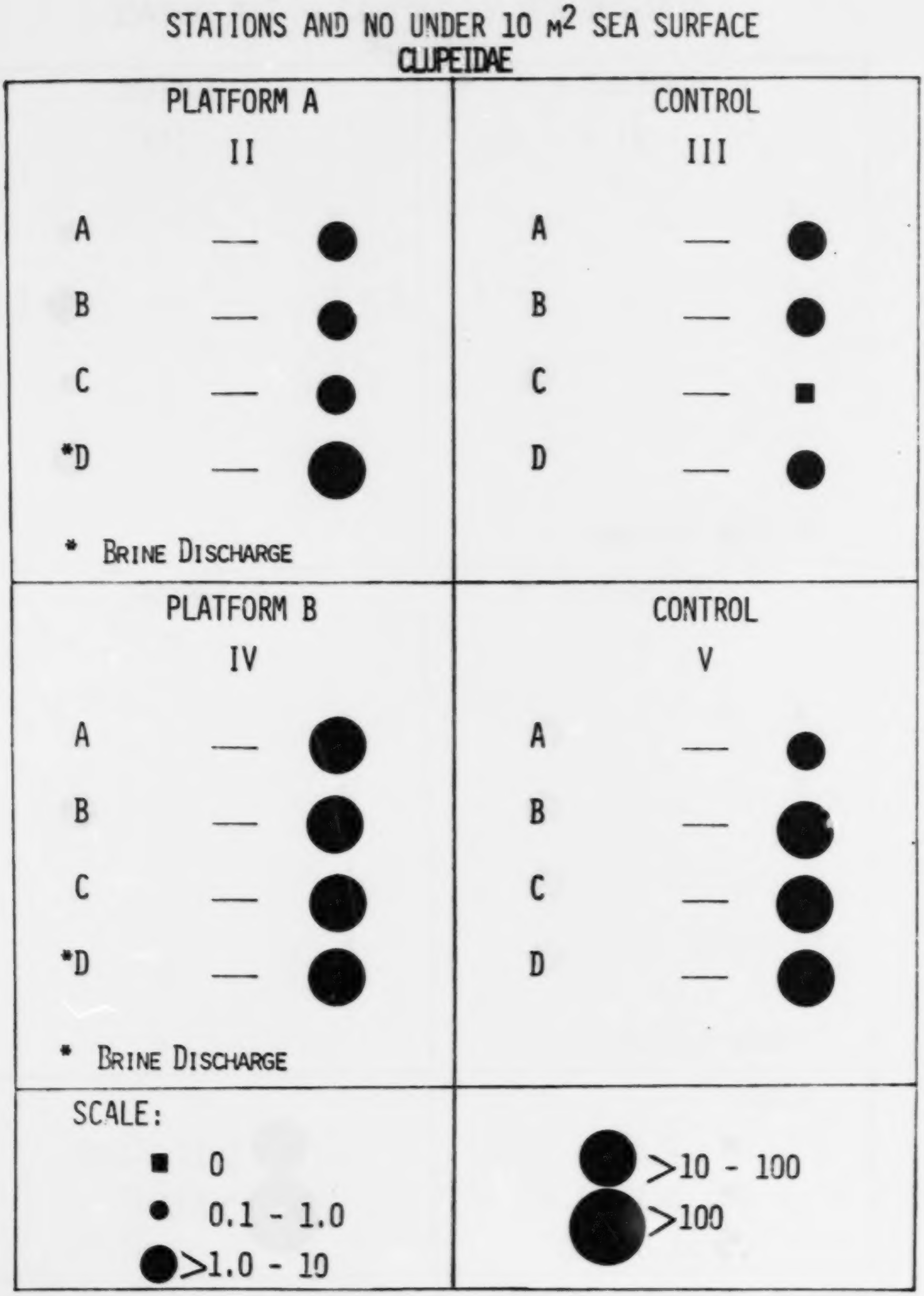


Figure 16. Comparison of abundance and distribution of Clupeidae between platforms and control satellites for Cruise 1.

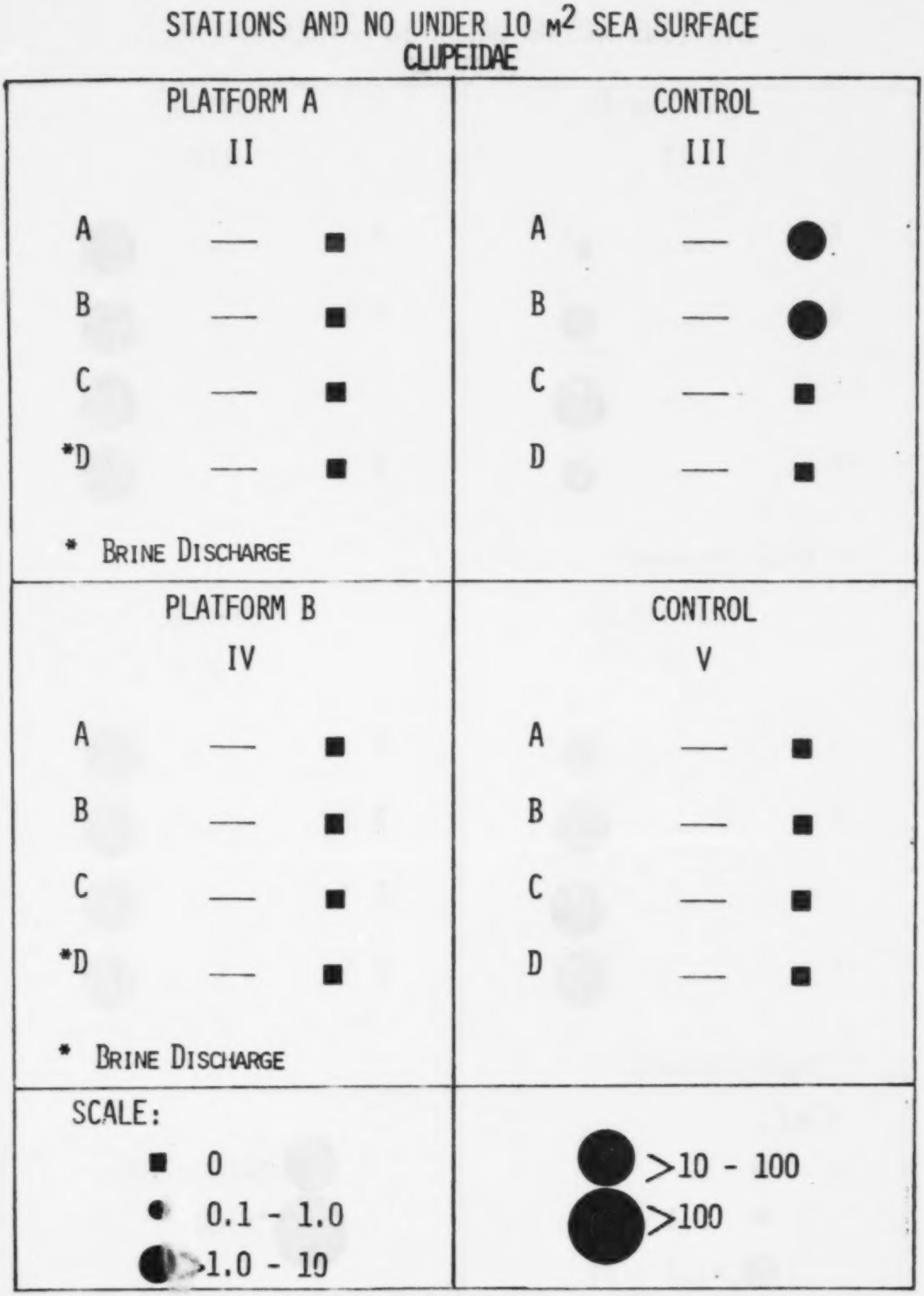


Figure 17. Comparison of abundance and distribution of Clupeidae between platforms and control satellites for Cruise 2.

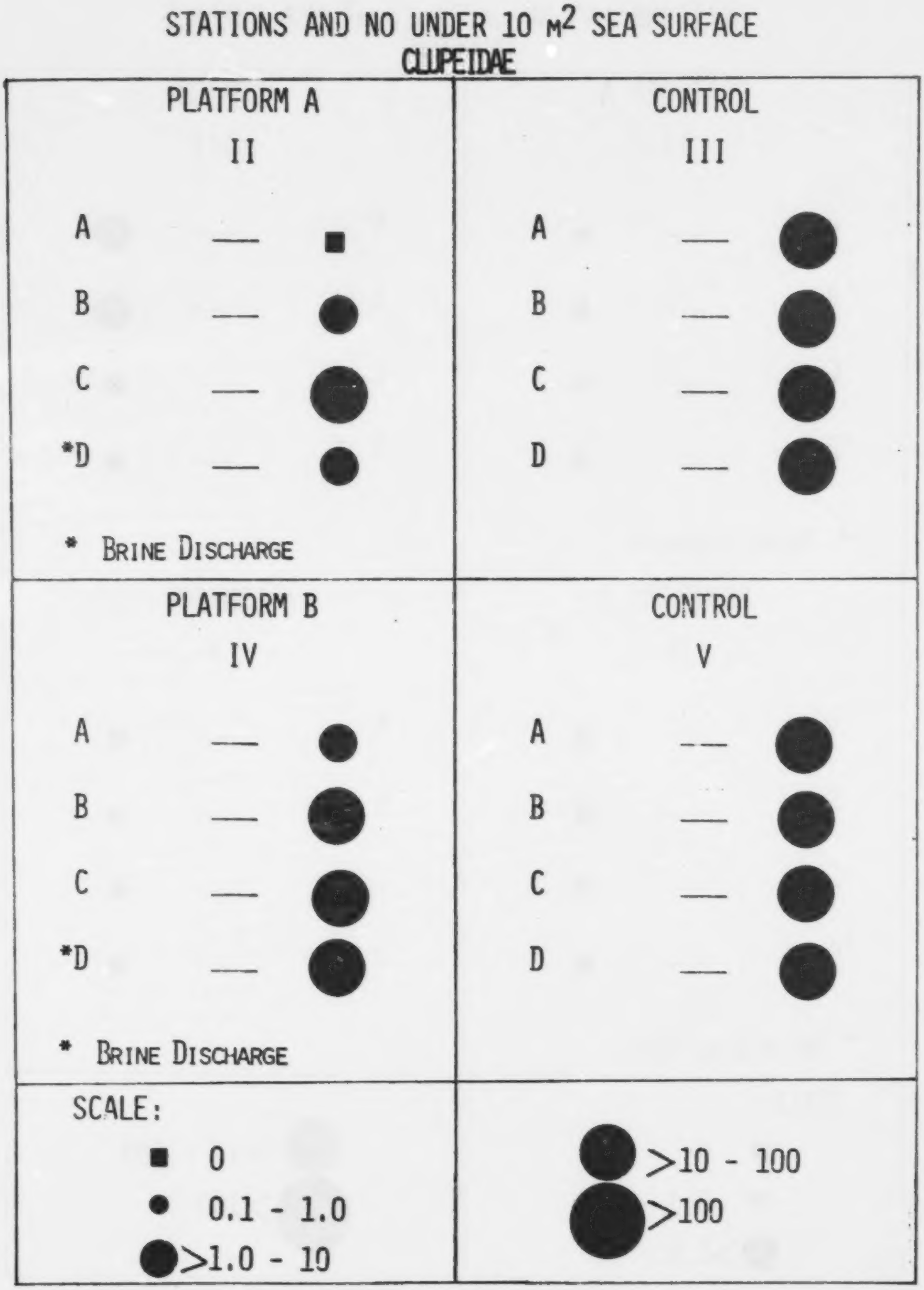


Figure 18. Comparison of abundance and distribution of Clupeidae between platforms and control satellites for Cruise 3.

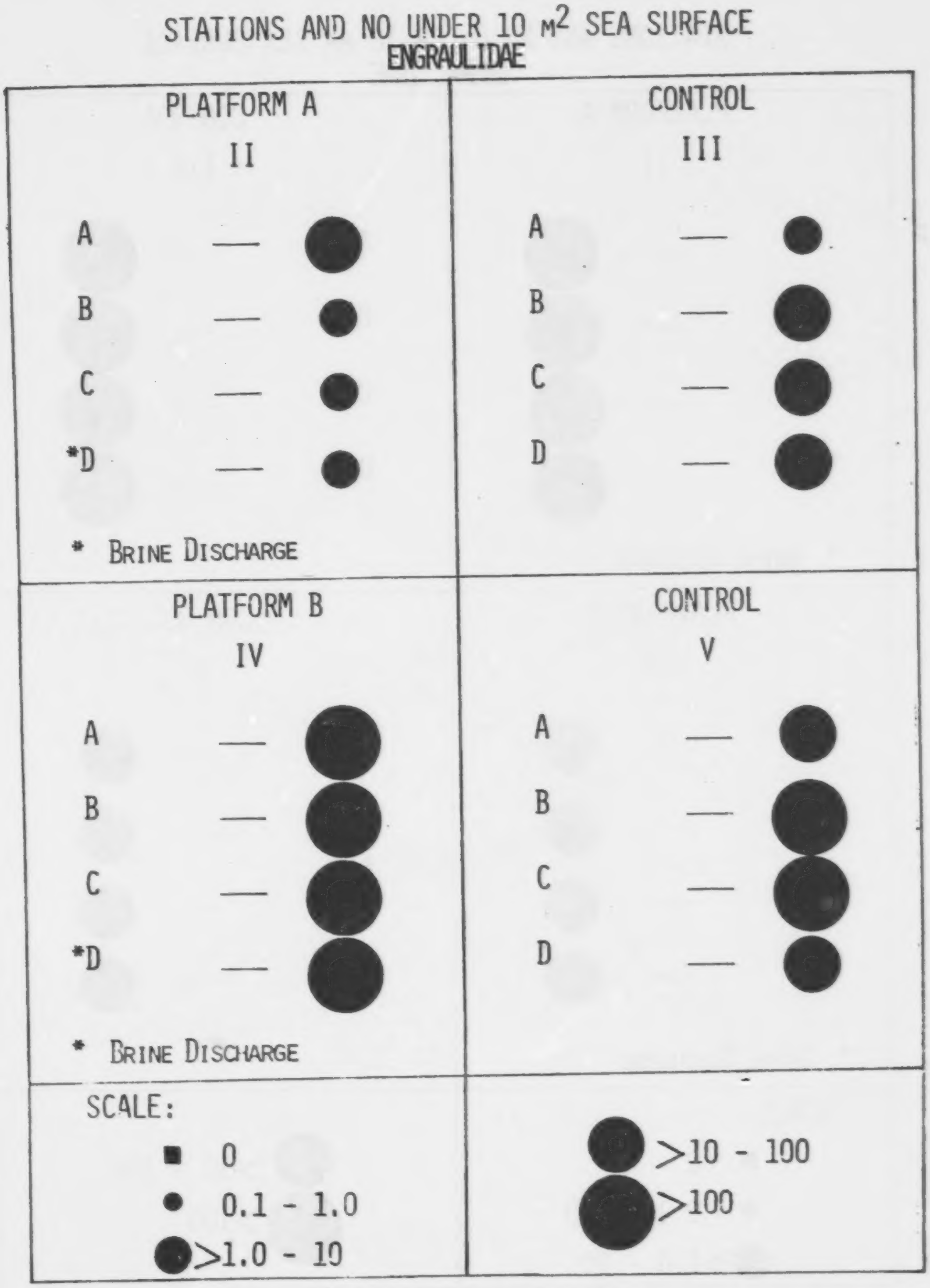


Figure 19. Comparison of abundance and distribution of Engraulidae between platforms and control satellites for Cruise 1.

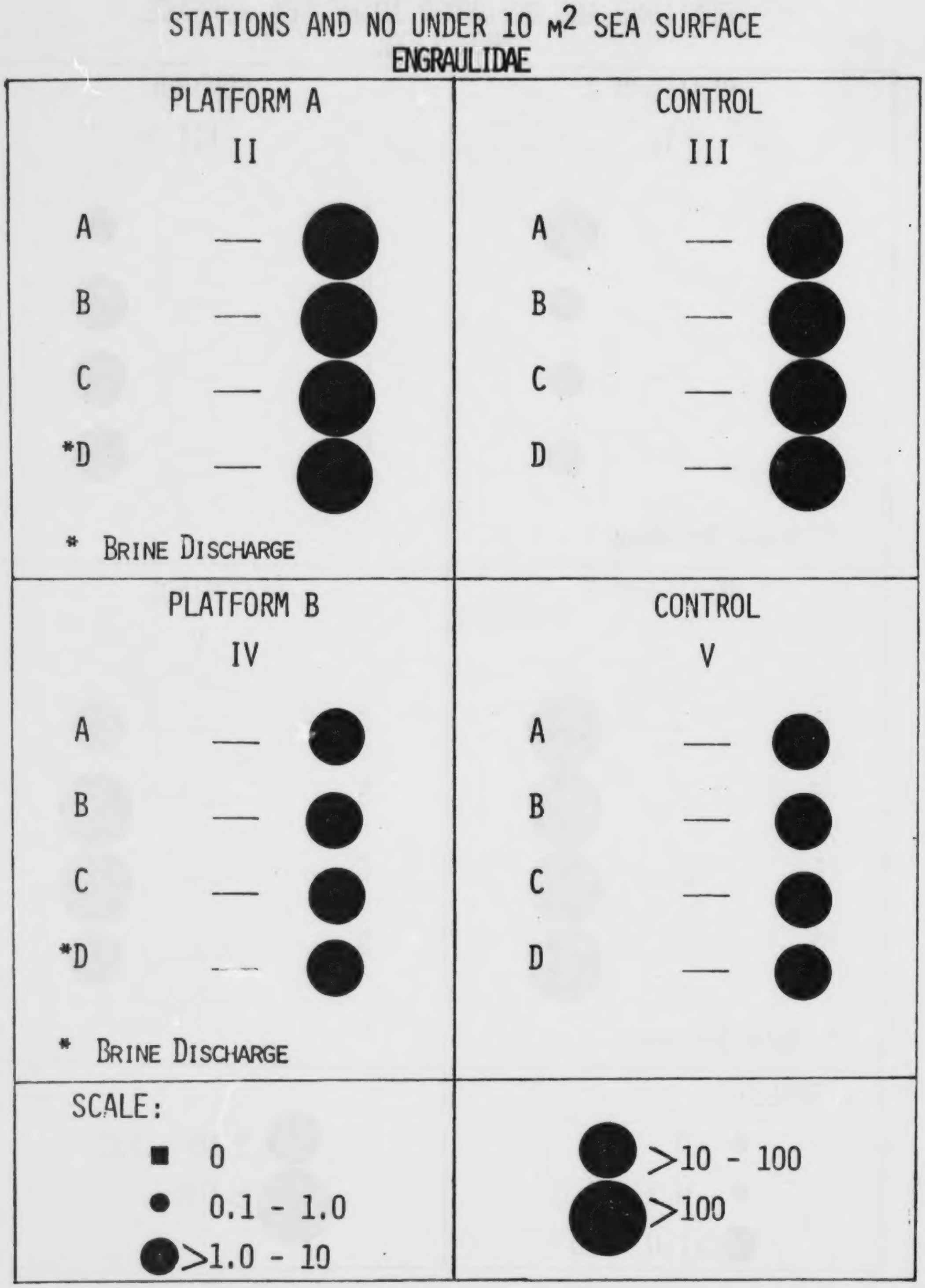


Figure 20. Comparison of abundance and distribution of Engraulidae between platforms and control satellites for Cruise 2.

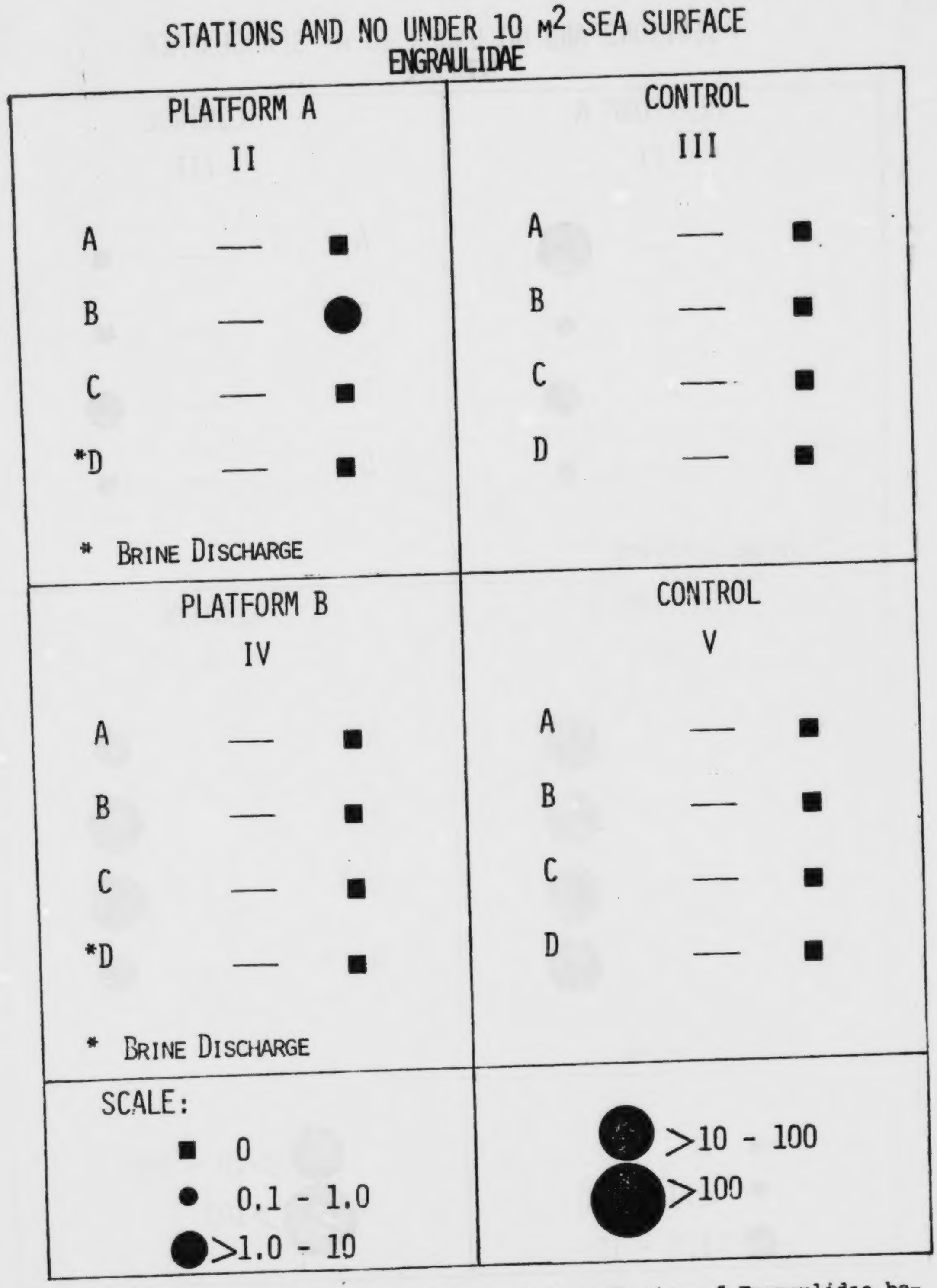


Figure 21. Comparison of abundance and distribution of Engraulidae between platforms and control satellites for Cruise 3.

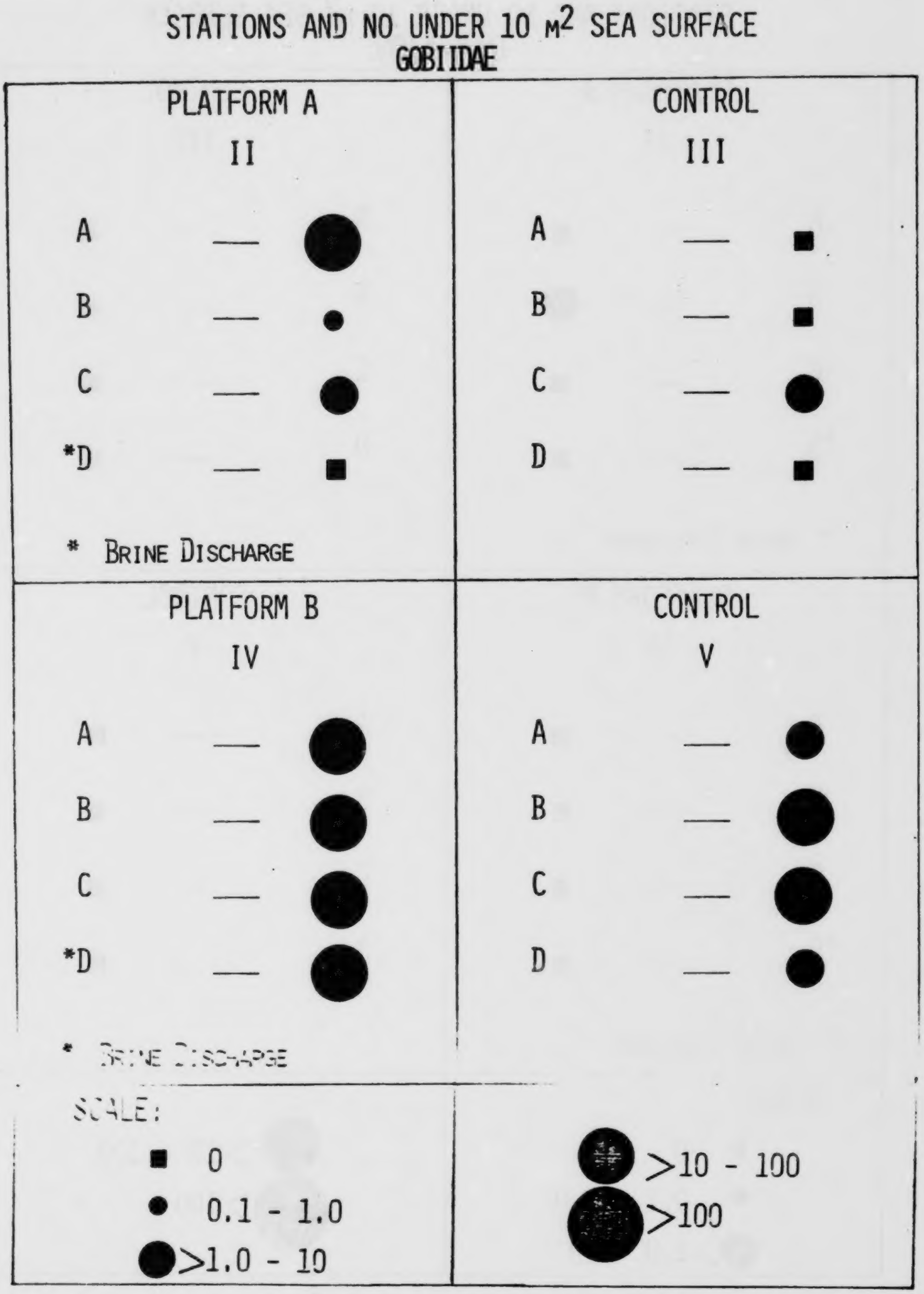
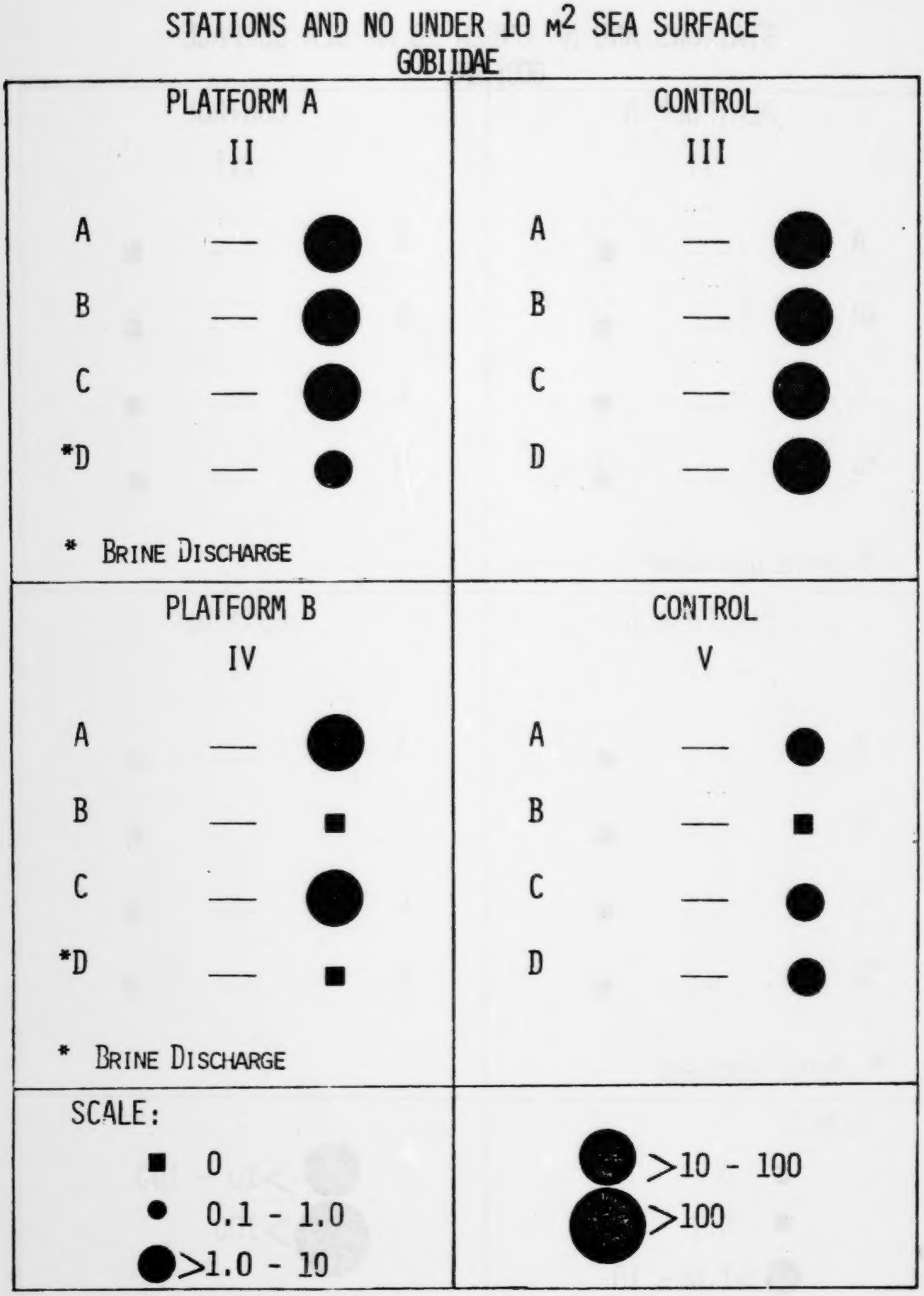


Figure 22. Comparison of abundance and distribution of Gobiidae between platforms and control satellites for Cruise 1.



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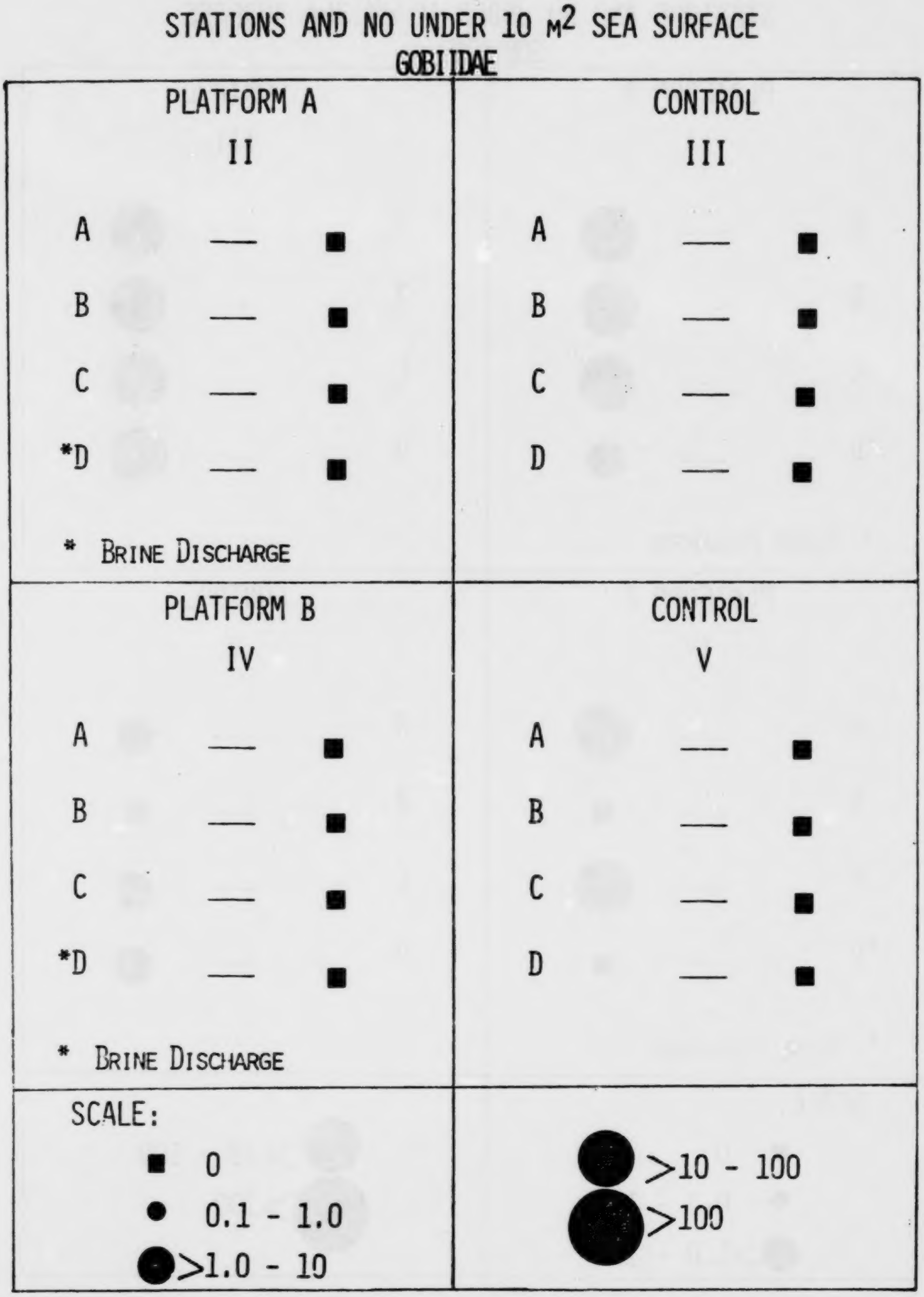

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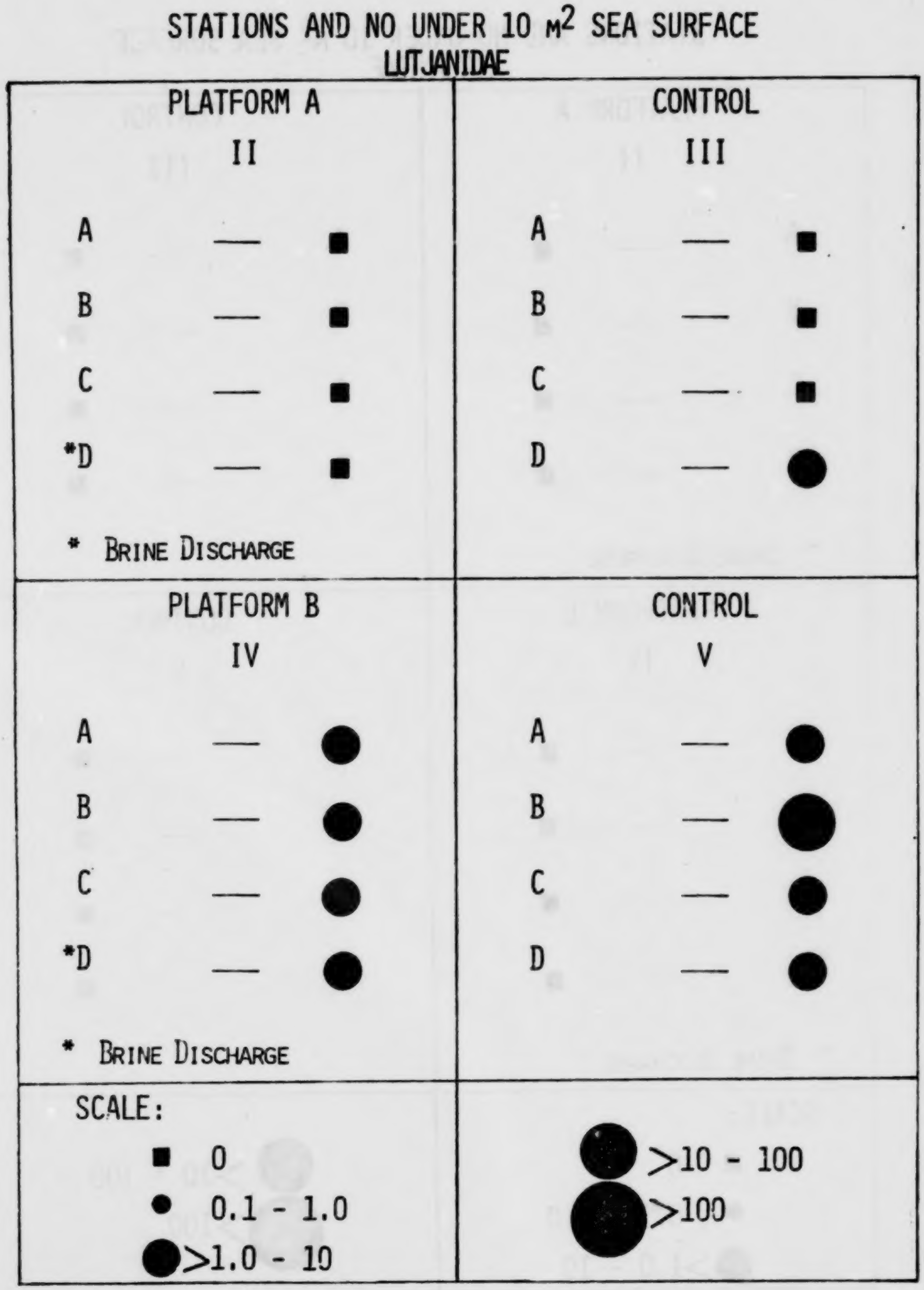

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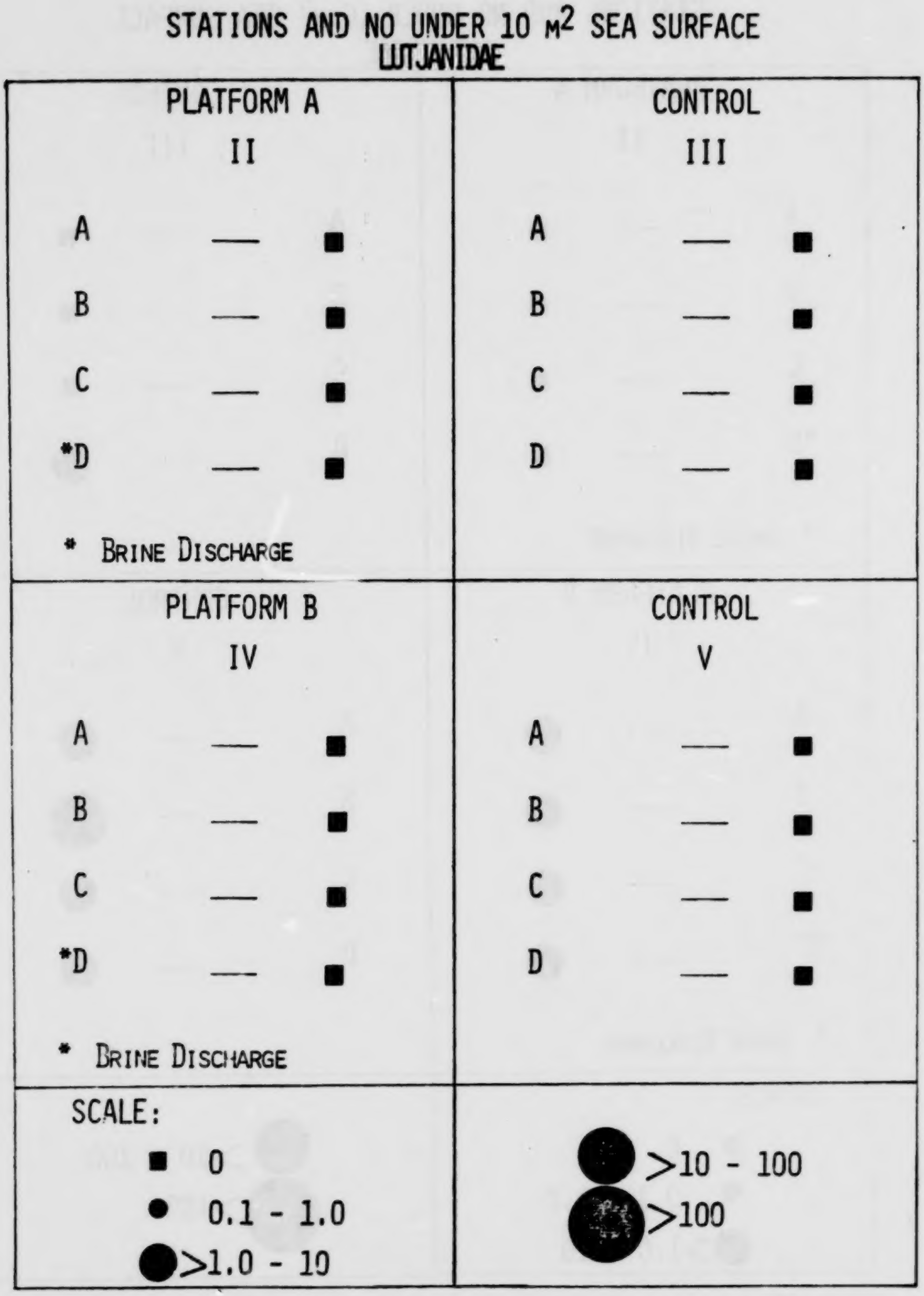


Figure 26. Comparison of abundance and distribution of Lutjanidae between platforms and control satellites for Cruise 2.

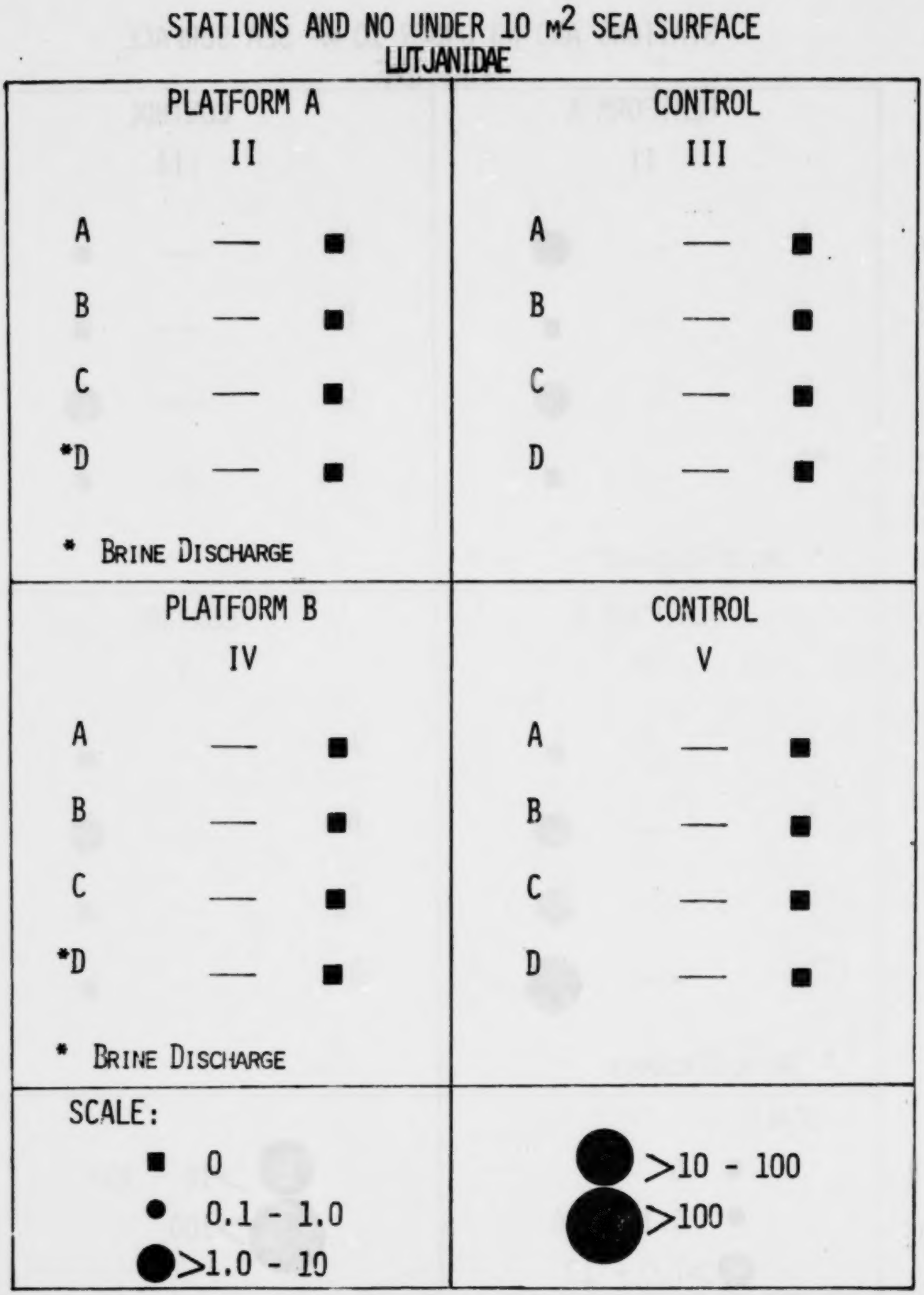
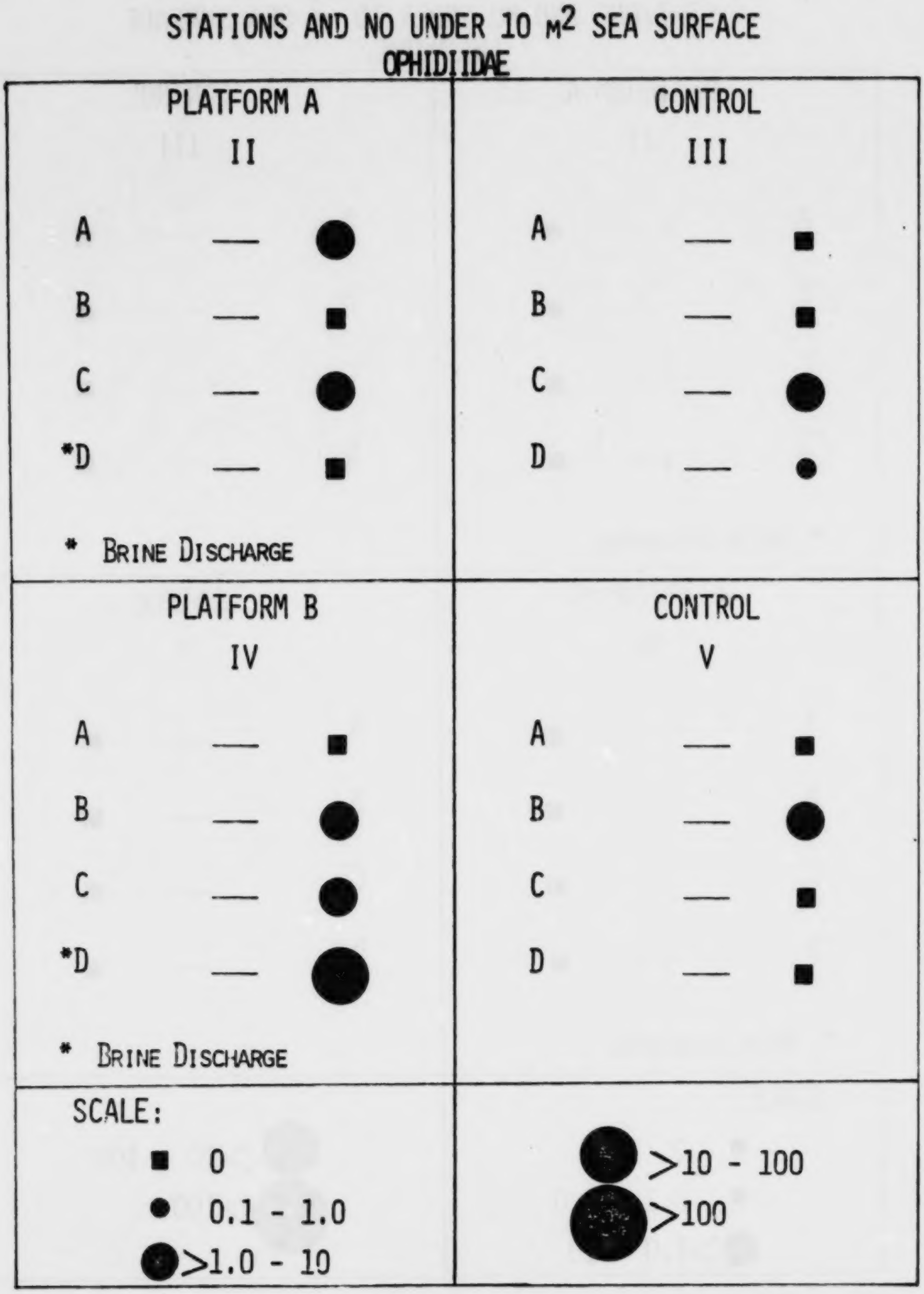


Figure 27. Comparison of abundance and distribution of Lutjanidae between platforms and control satellites for Cruise 3.



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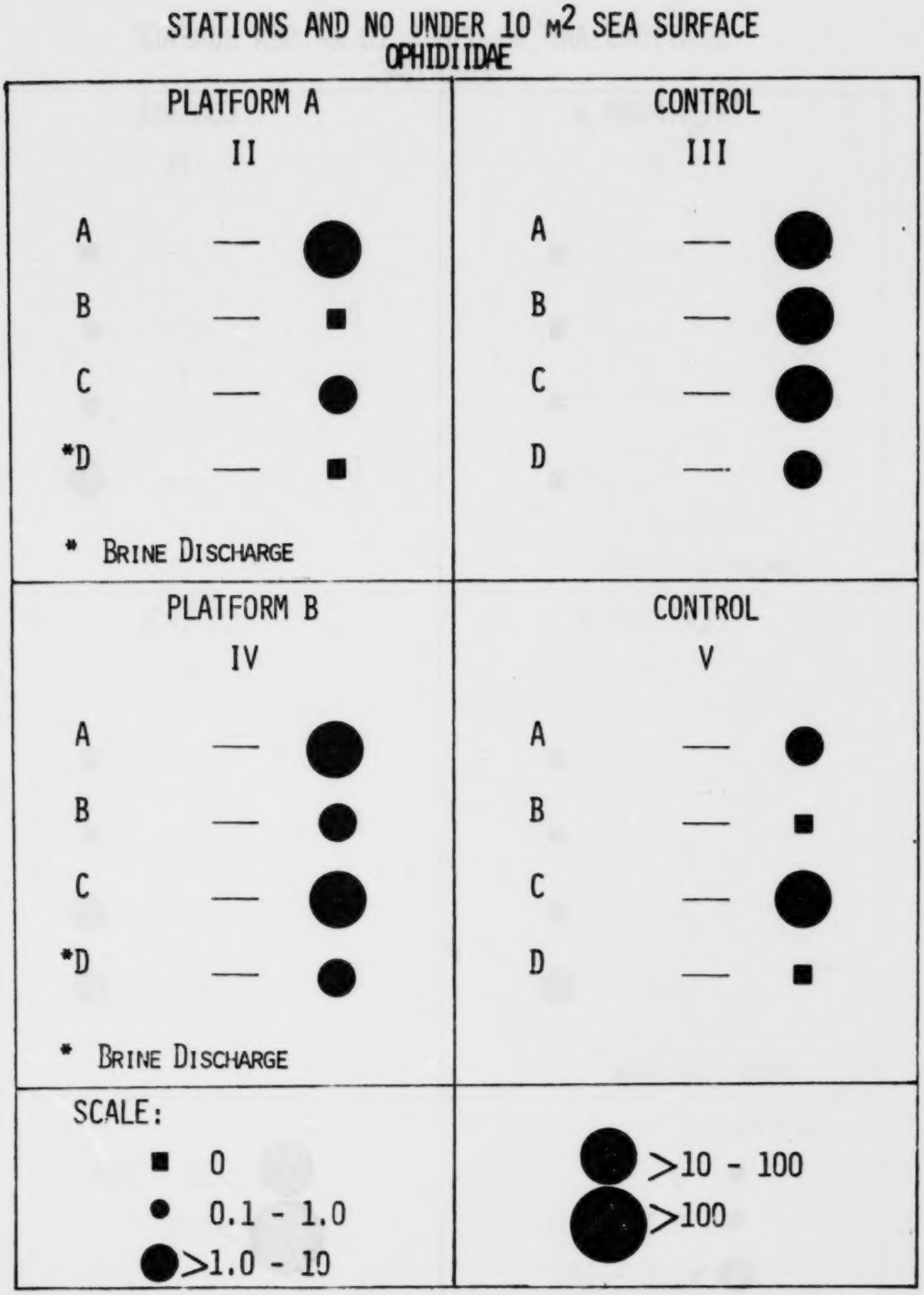

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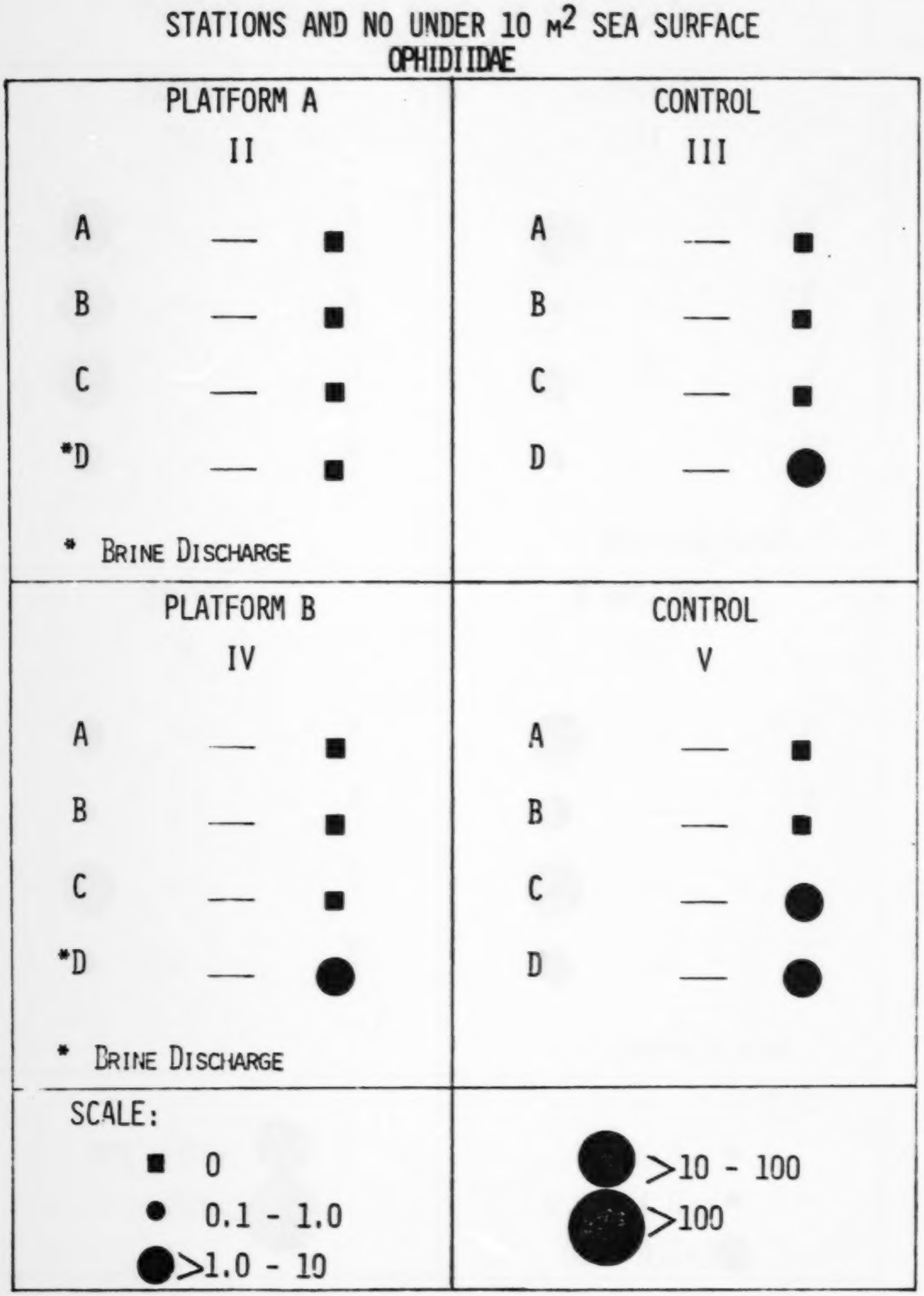

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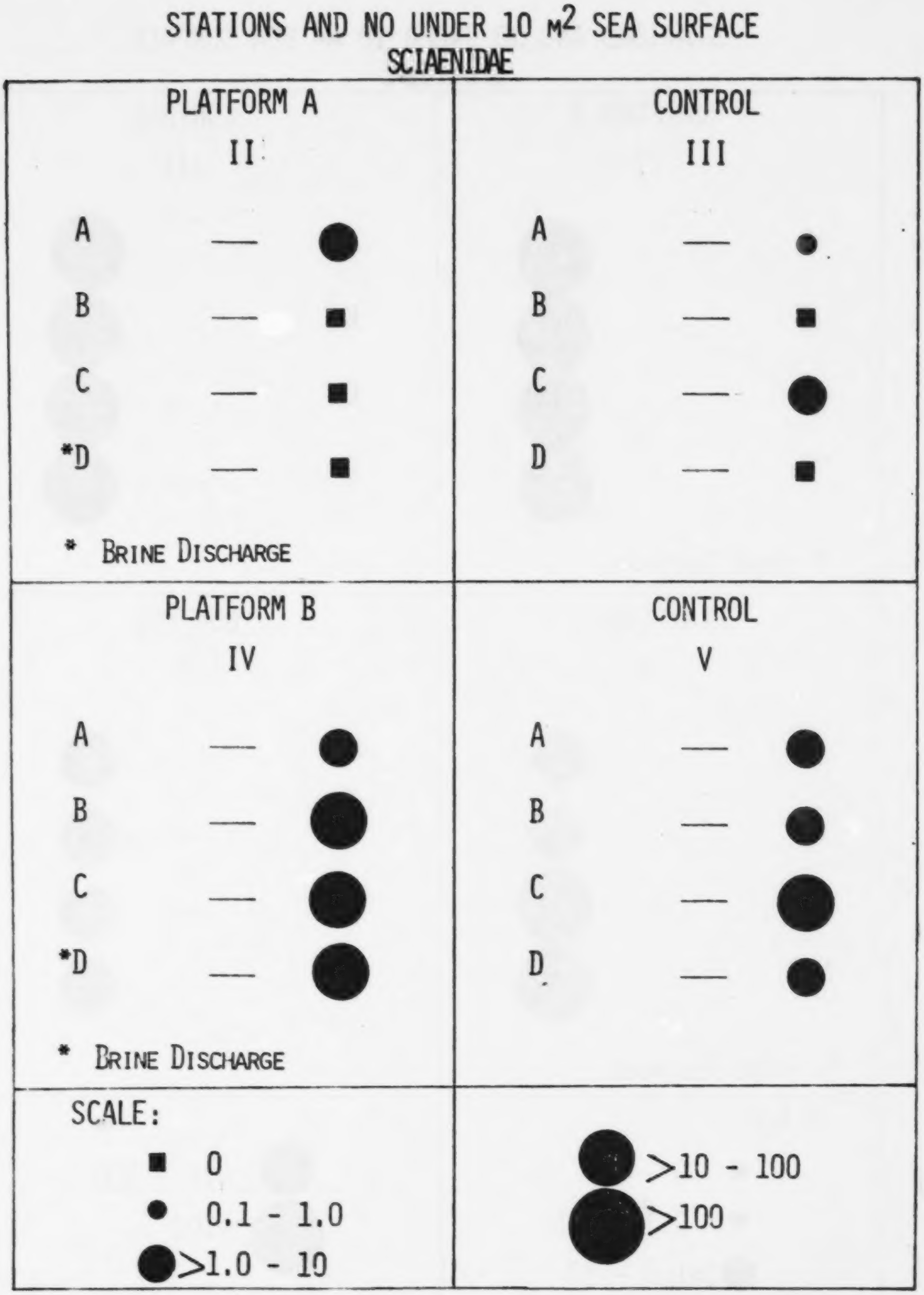

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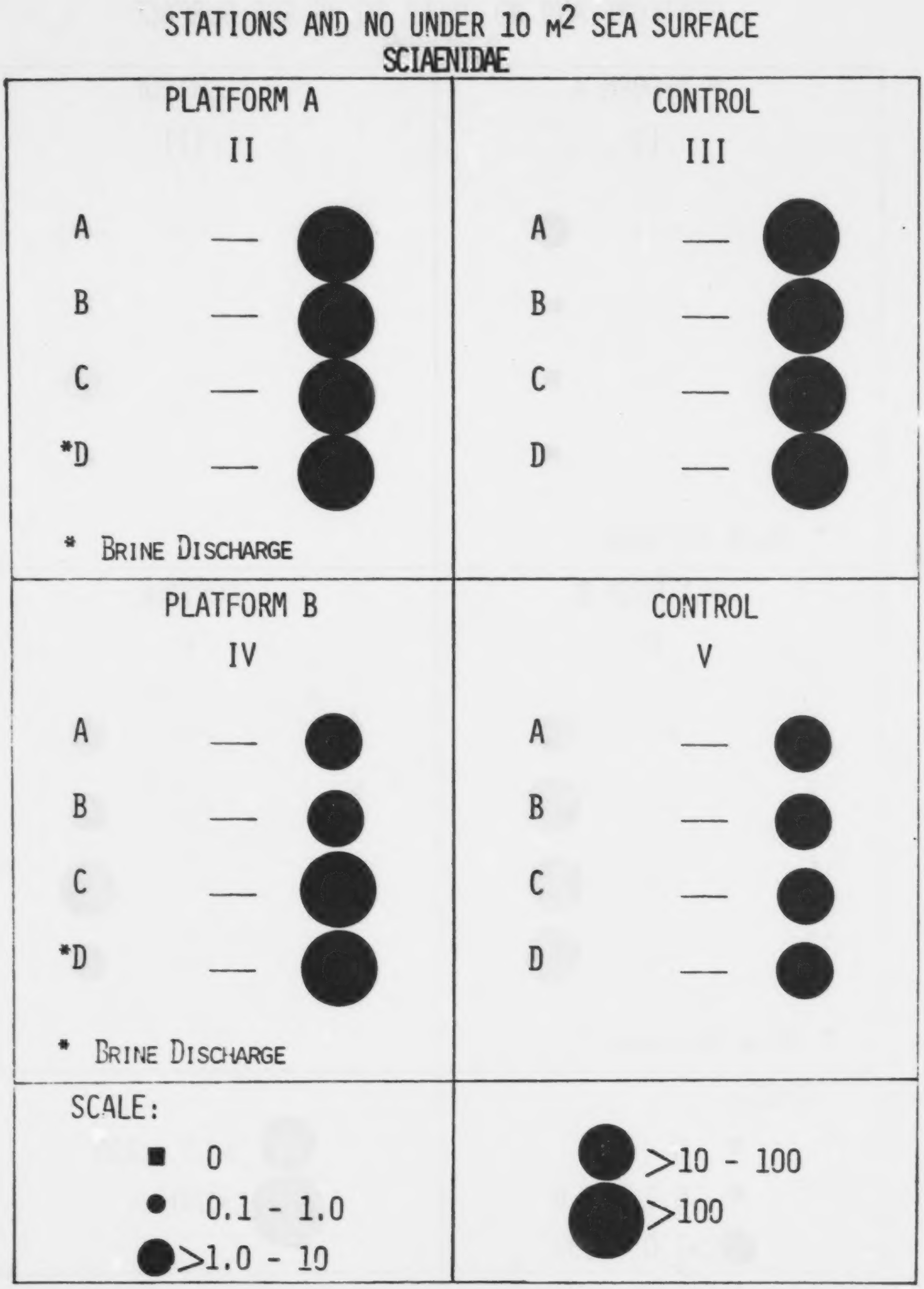

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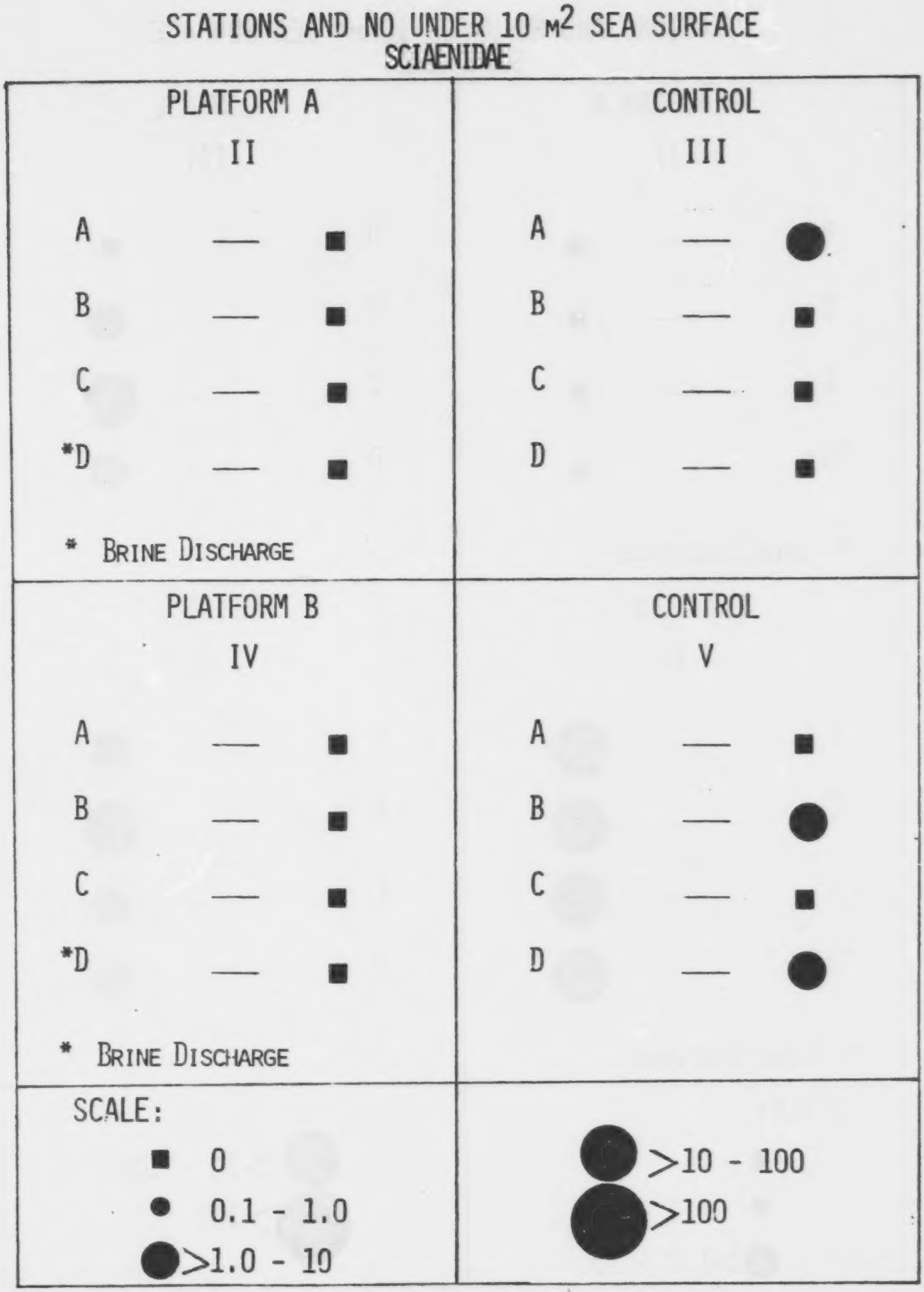

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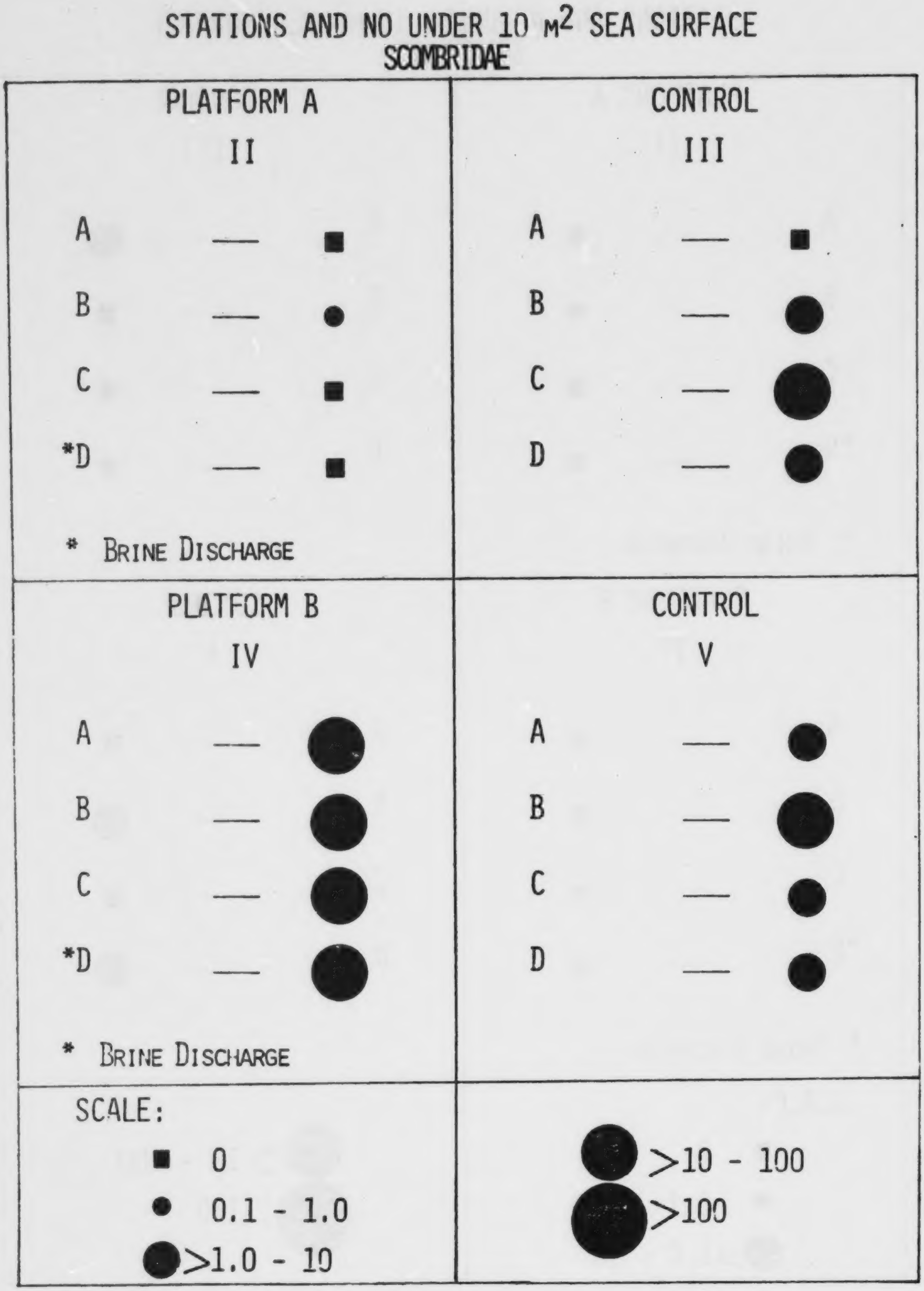

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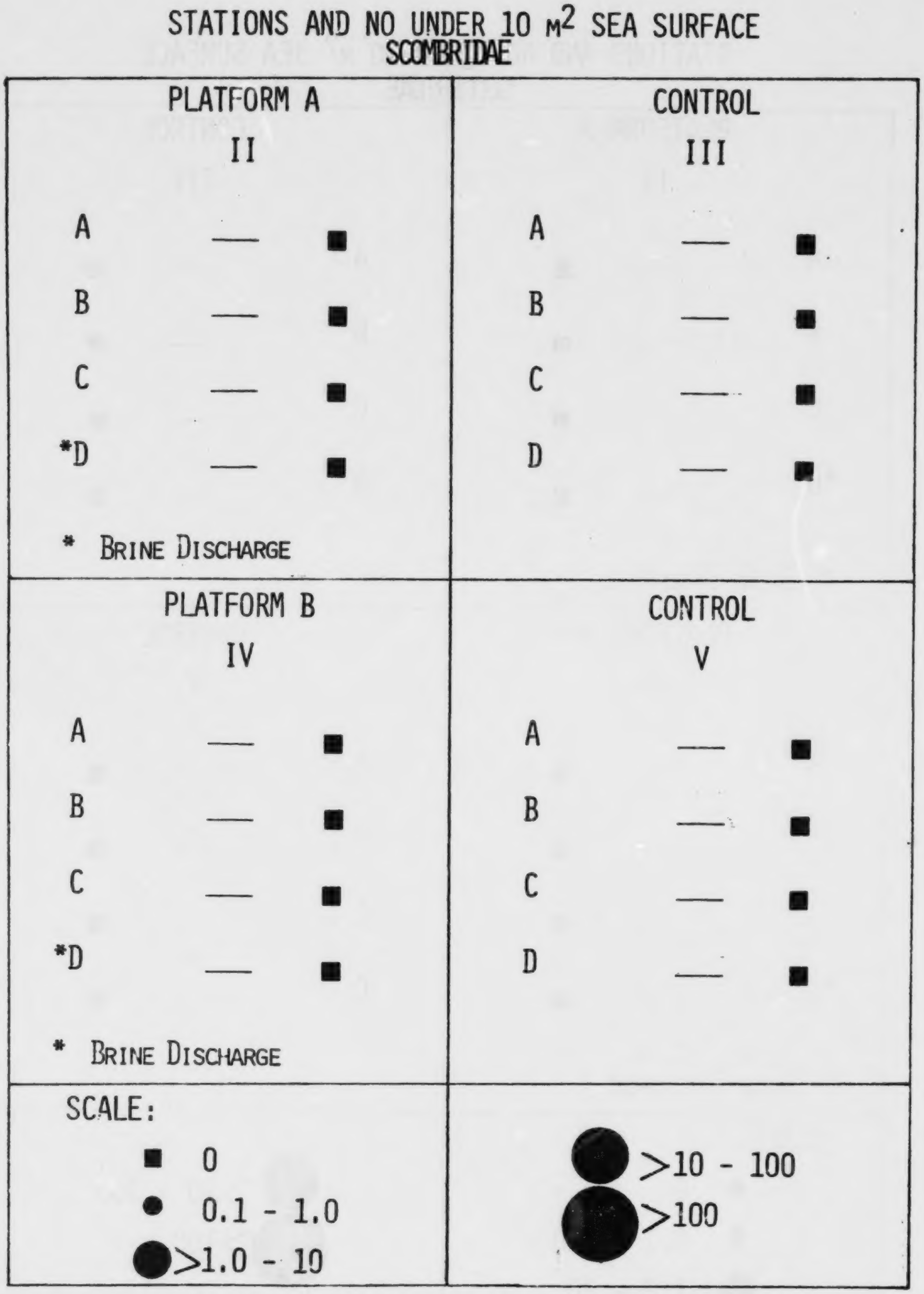


Figure 35. Comparison of abundance and distribution of Scombridae between platforms and control satellites for Cruise 2.

STATIONS AND NO UNDER 10 M^2 SEA SURFACE

SCOMBRIDAE

PLATFORM A II		CONTROL III	
A	— ■	A	— ■
B	— ■	B	— ■
C	— ■	C	— ■
*D	— ■	D	— ■

* BRINE DISCHARGE

PLATFORM B IV		CONTROL V	
A	— ■	A	— ■
B	— ■	B	— ■
C	— ■	C	— ■
*D	— ■	D	— ■

* BRINE DISCHARGE

SCALE:

■	0
•	0.1 - 1.0
●	>1.0 - 10
●	>10 - 100
⬤	>100

Figure 36. Comparison of abundance and distribution of Scombridae between platforms and control satellites for Cruise 3.

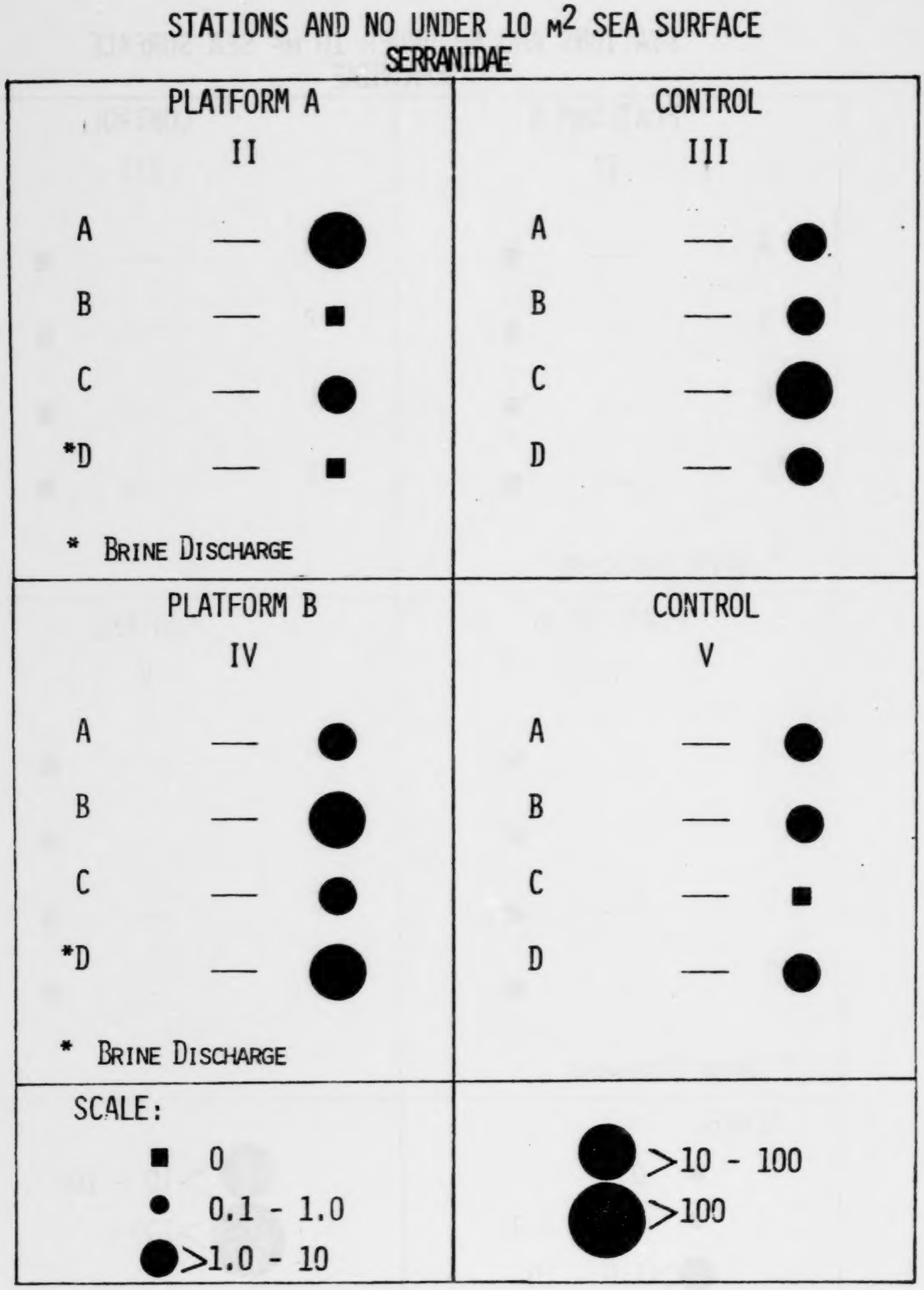


Figure 37. Comparison of abundance and distribution of Serranidae between platforms and control satellites for Cruise 1.

STATIONS AND NO UNDER 10 m^2 SEA SURFACE
SERRANIDAE

PLATFORM A
II

A — ■
B — ■
C — ■
*D — ■

* BRINE DISCHARGE

CONTROL
III

A — ■
B — ■
C — ■
D — ■

PLATFORM B
IV

A — ■
B — ■
C — ■
*D — ■

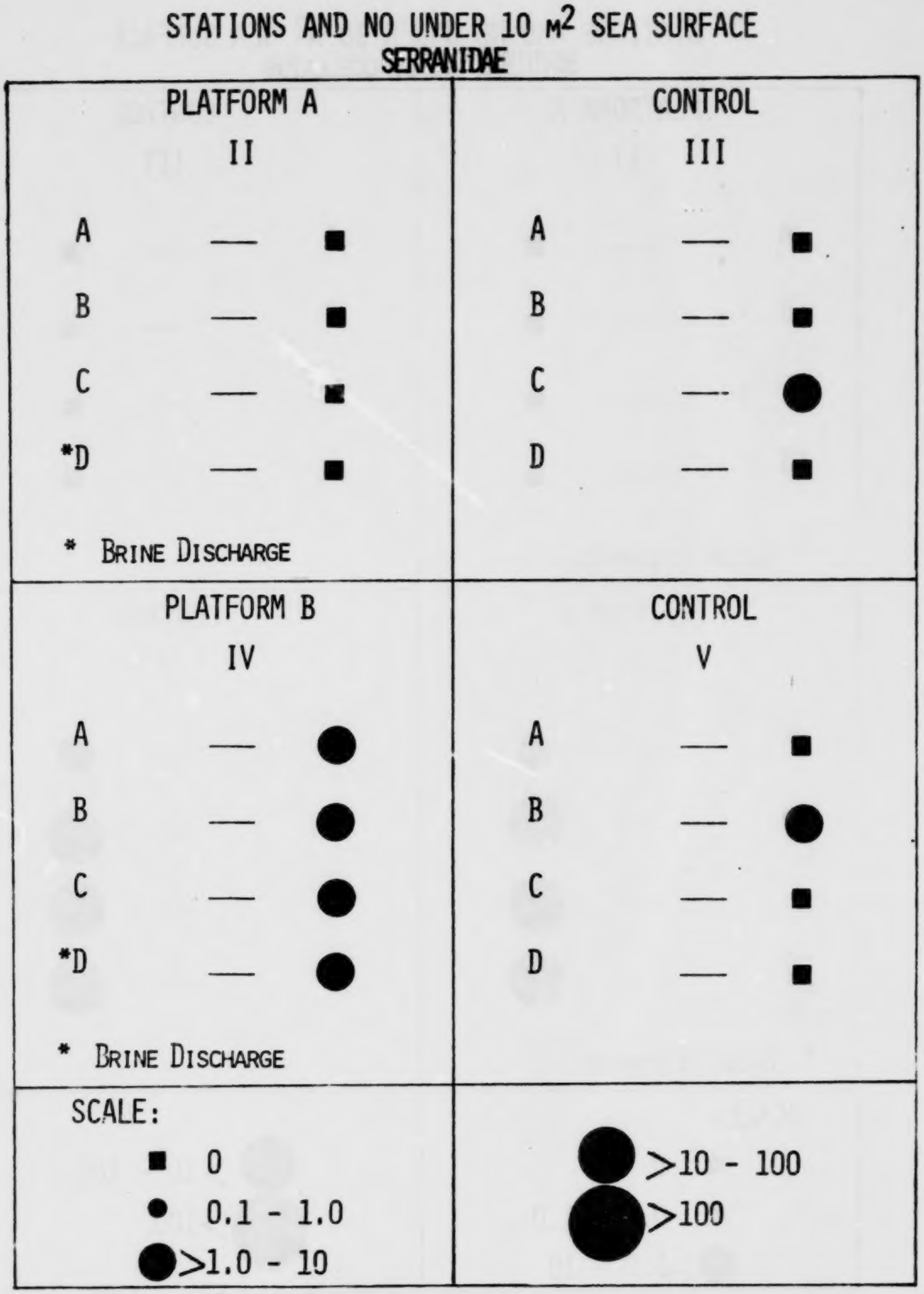
* BRINE DISCHARGE

CONTROL
V

A — ■
B — ■
C — ■
D — ■

SCALE:
■ 0
• 0.1 - 1.0
● >1.0 - 10
● >10 - 100
● >100

Figure 38. Comparison of abundance and distribution of Serranidae between platforms and control satellites for Cruise 2.



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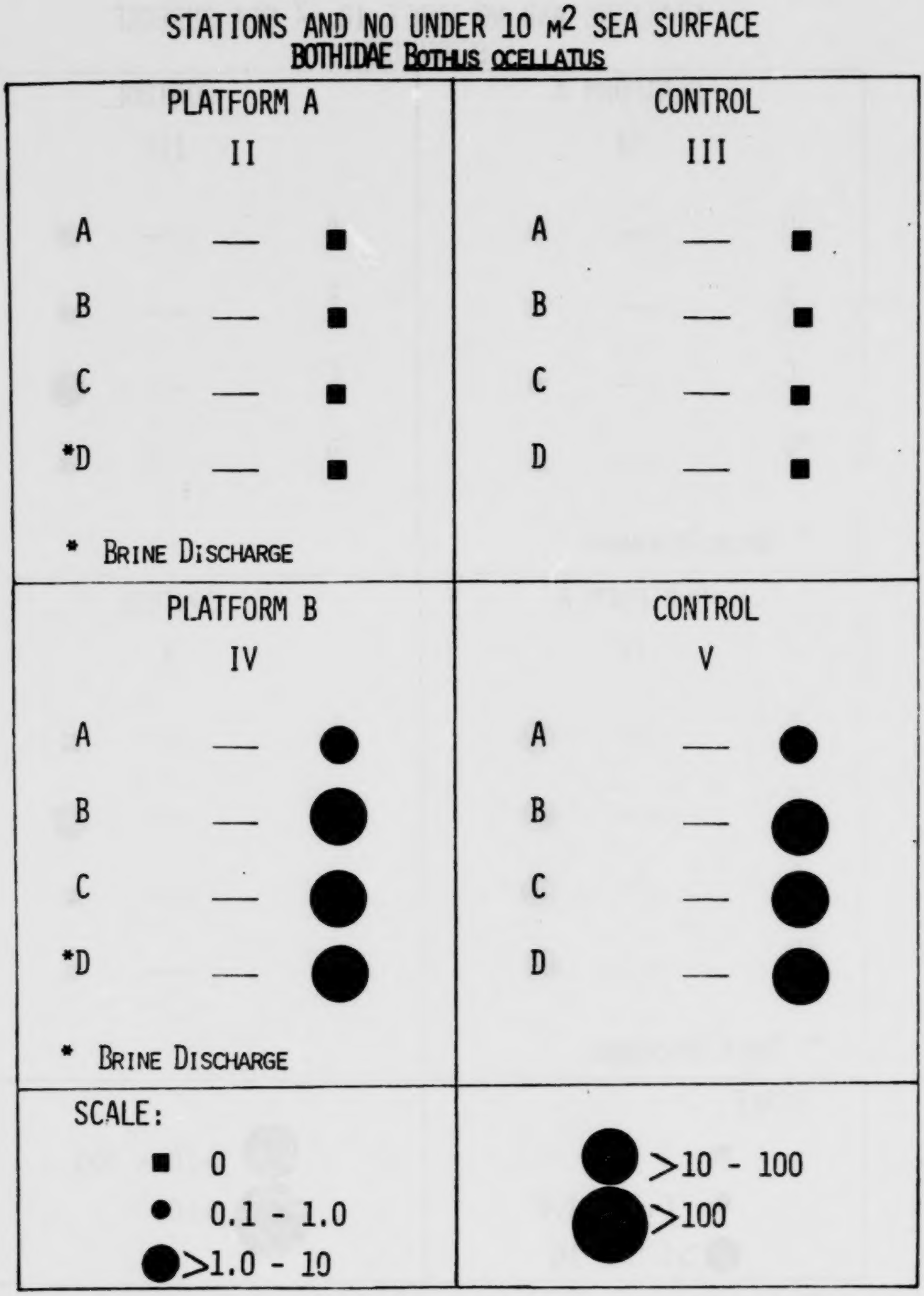

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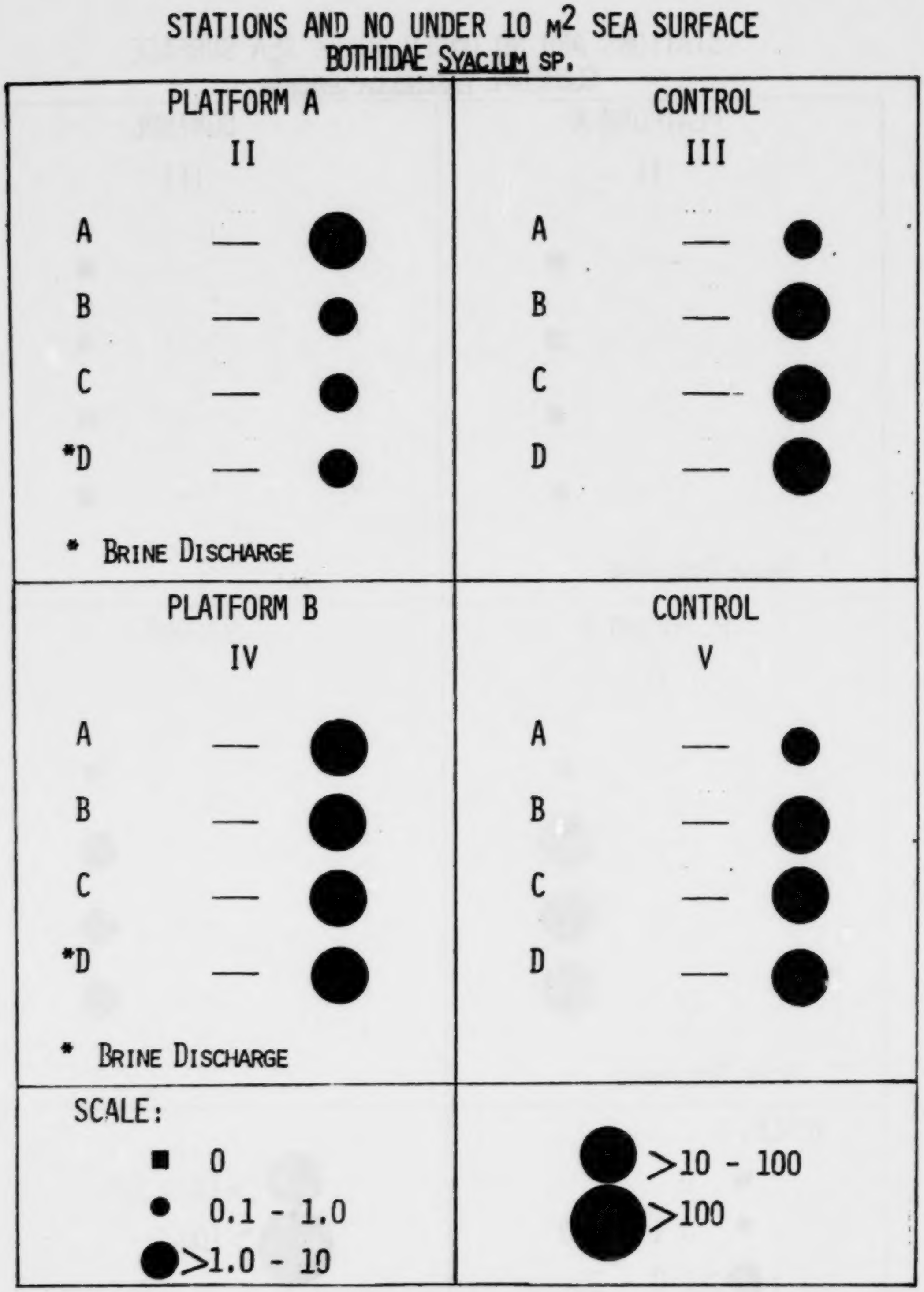

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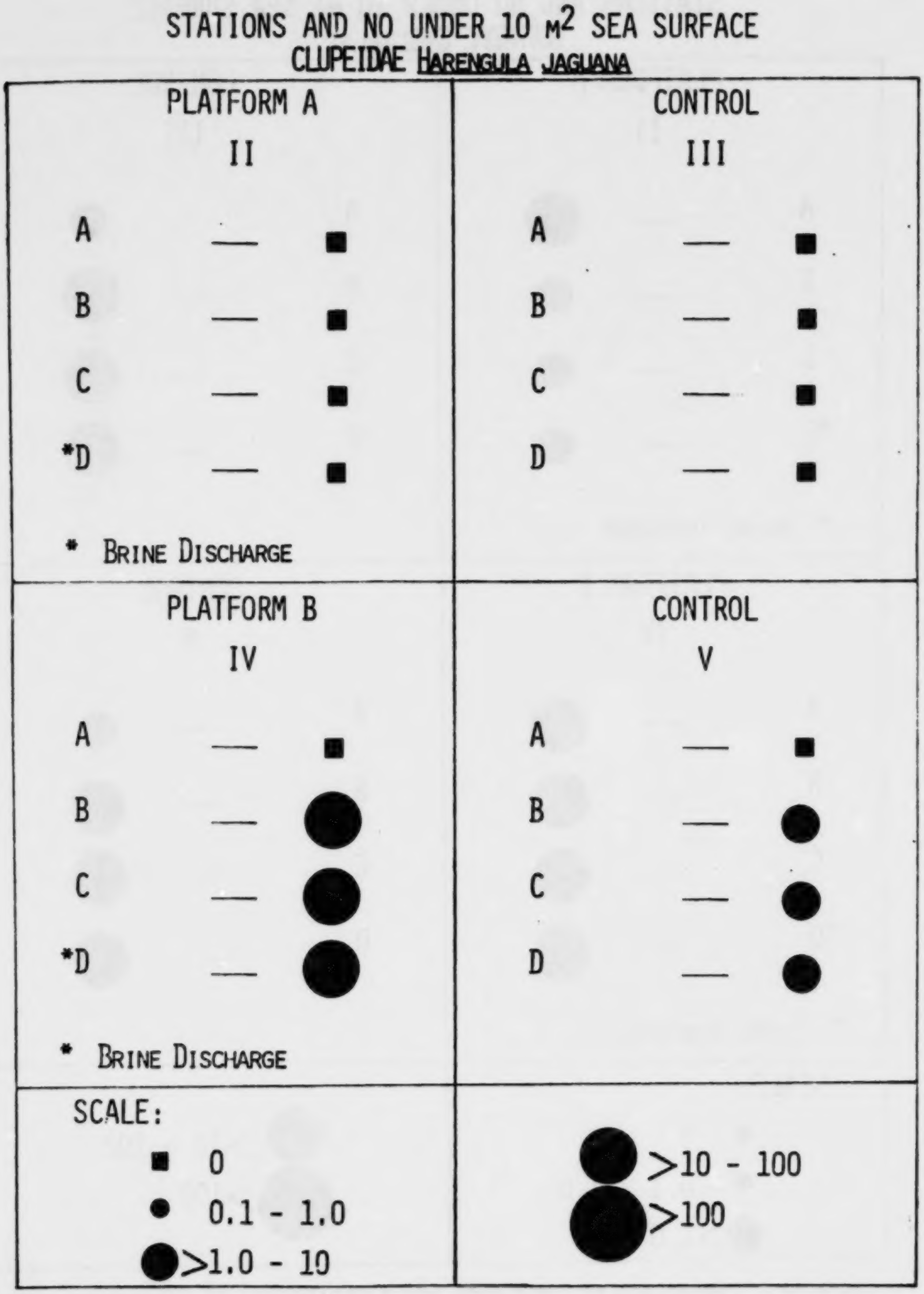

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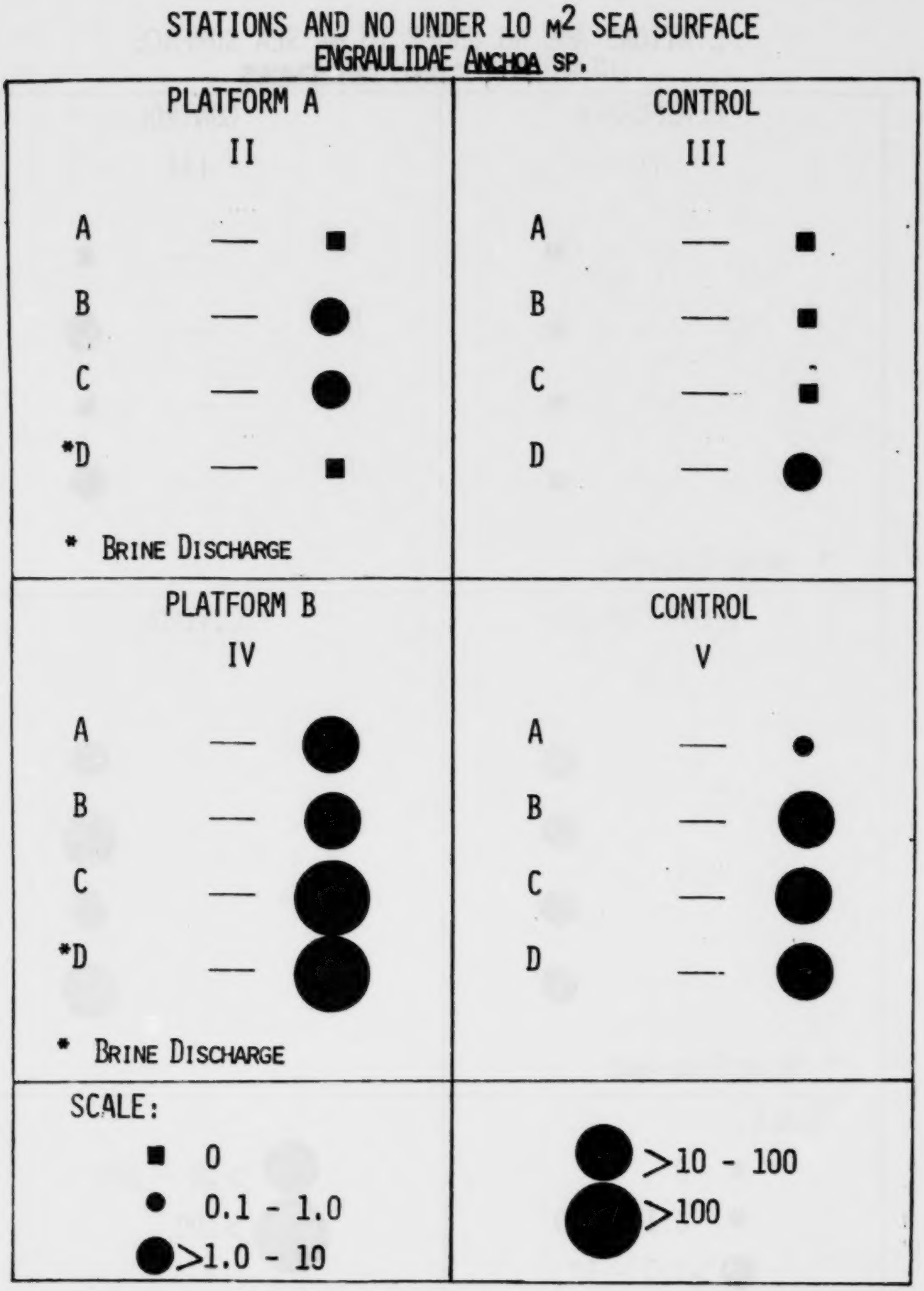

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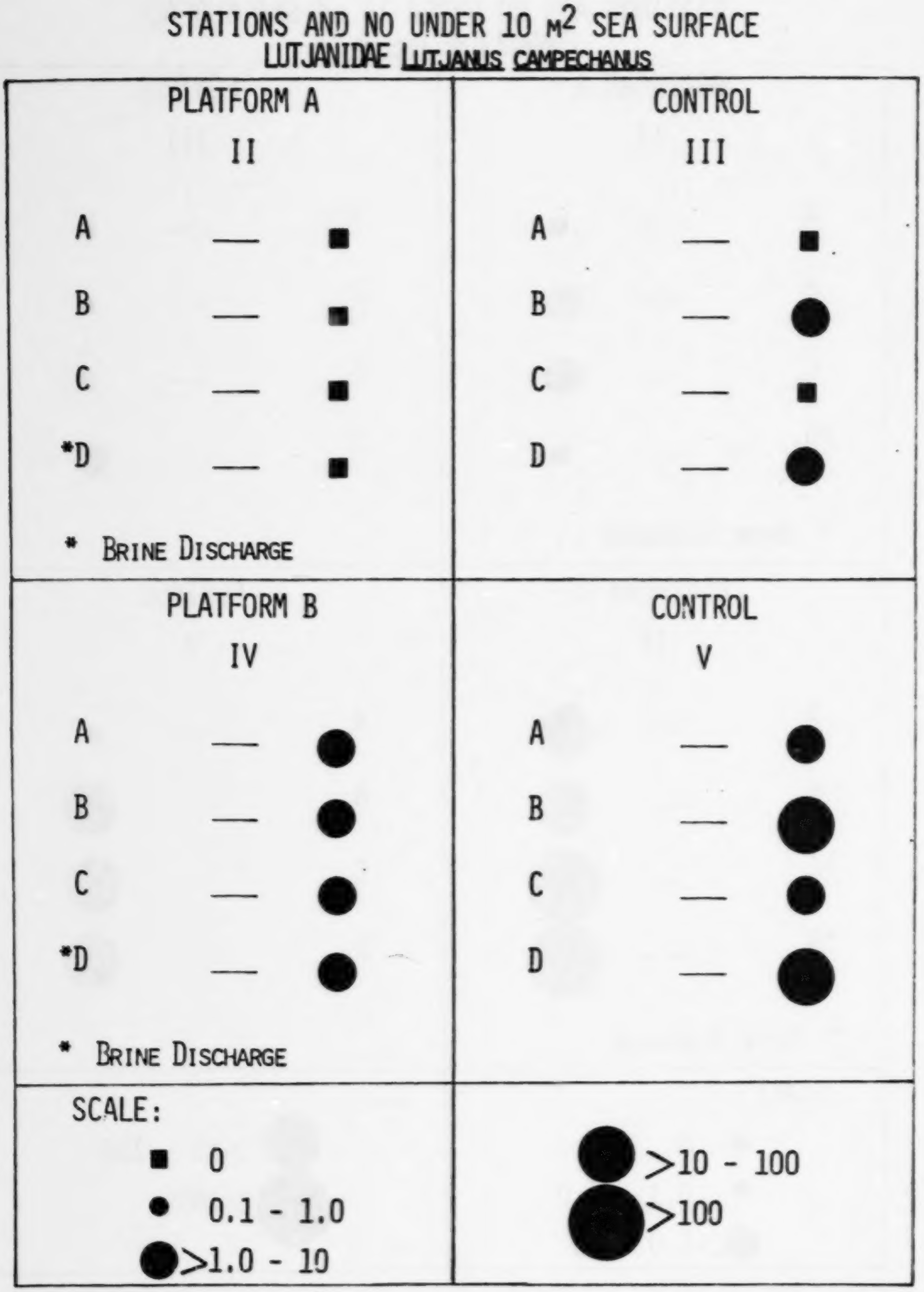

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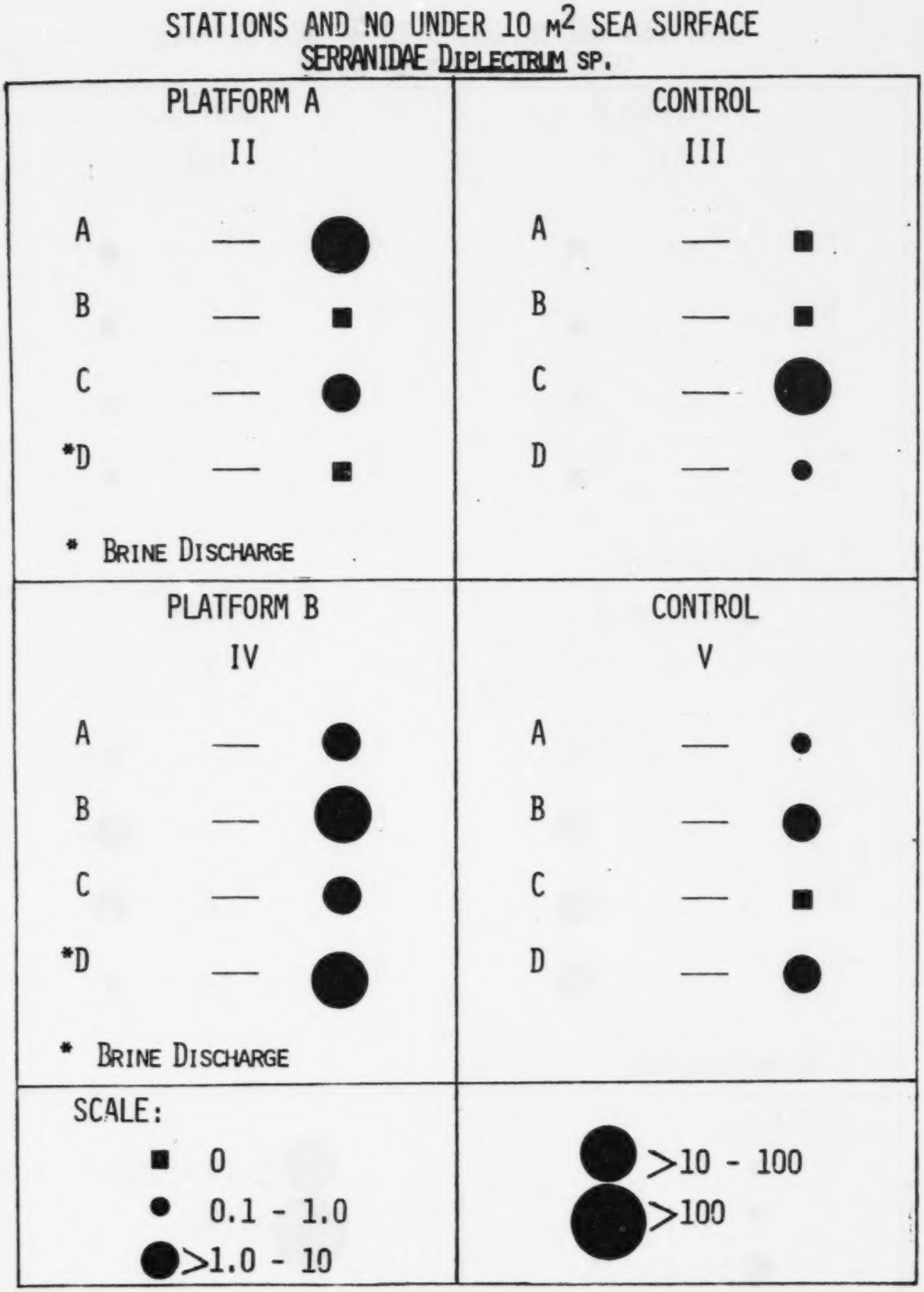

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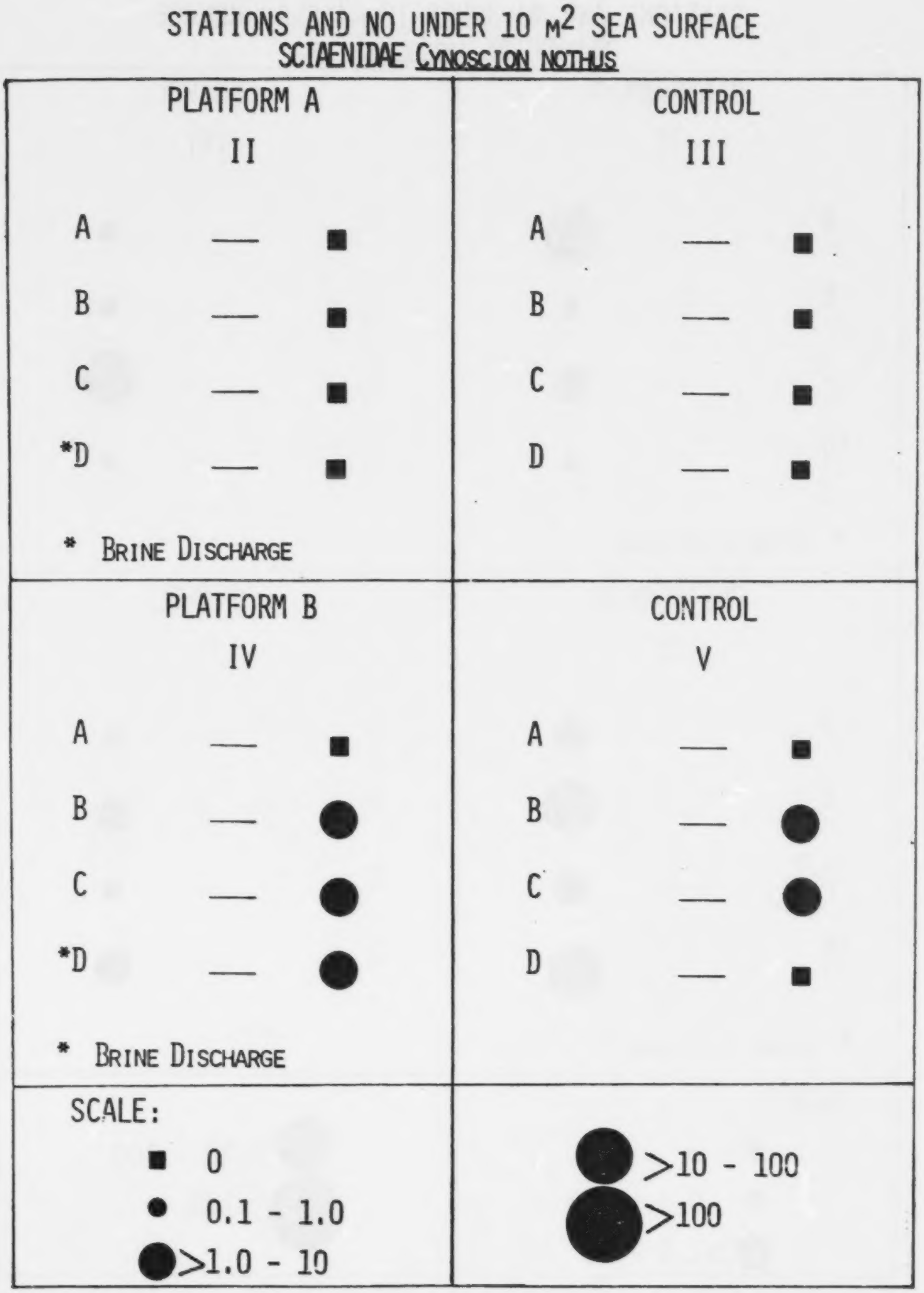

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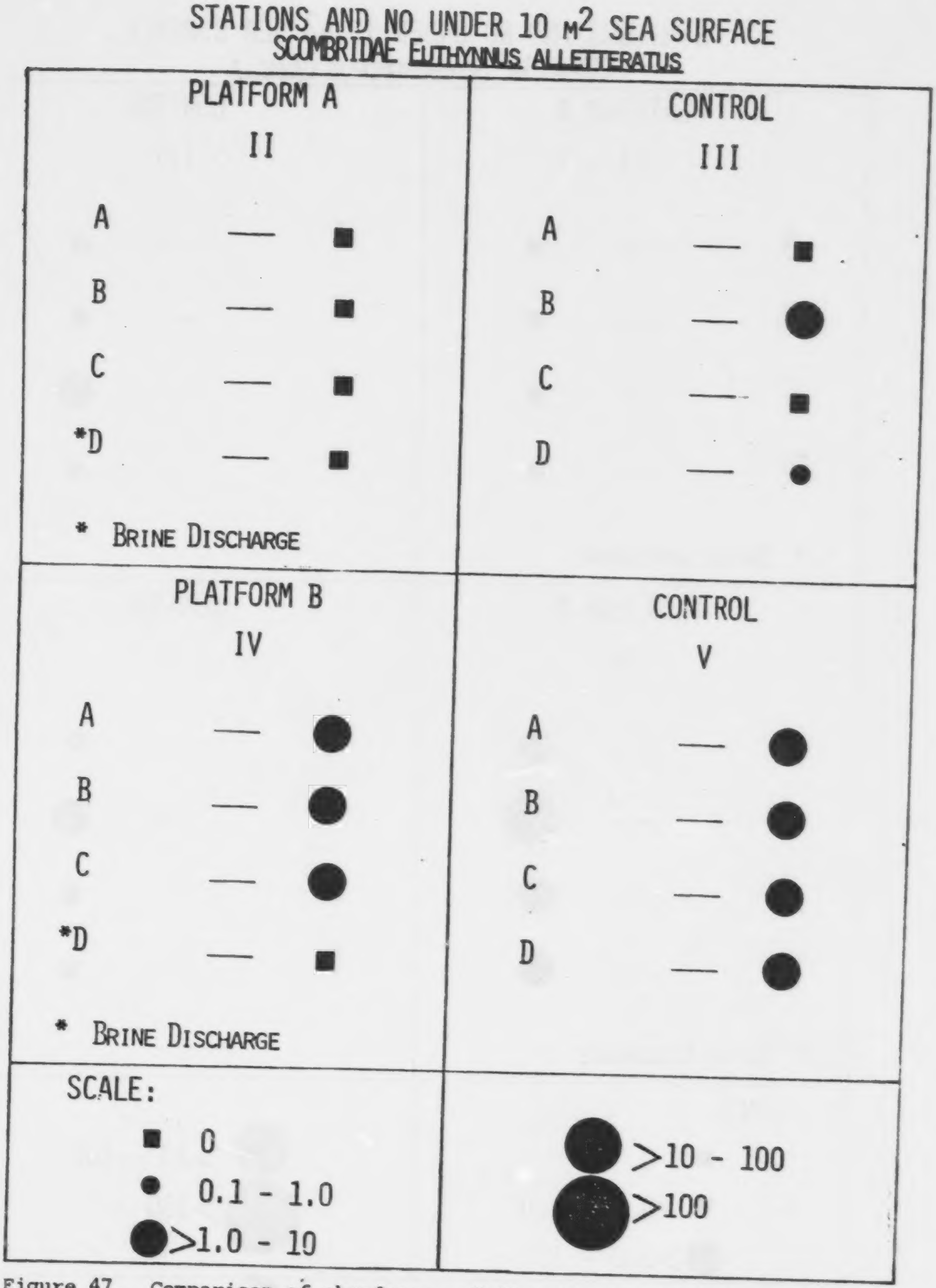

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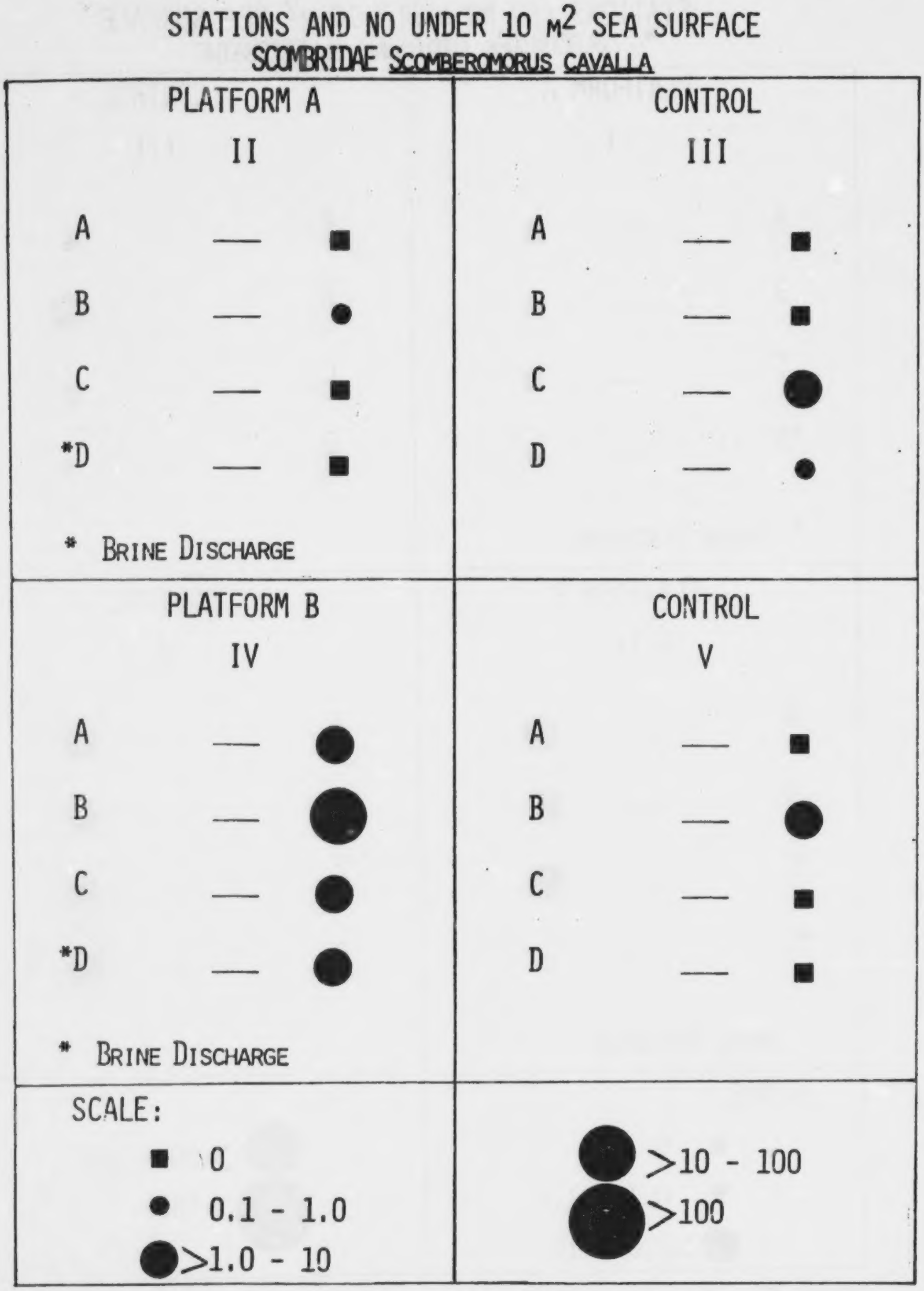

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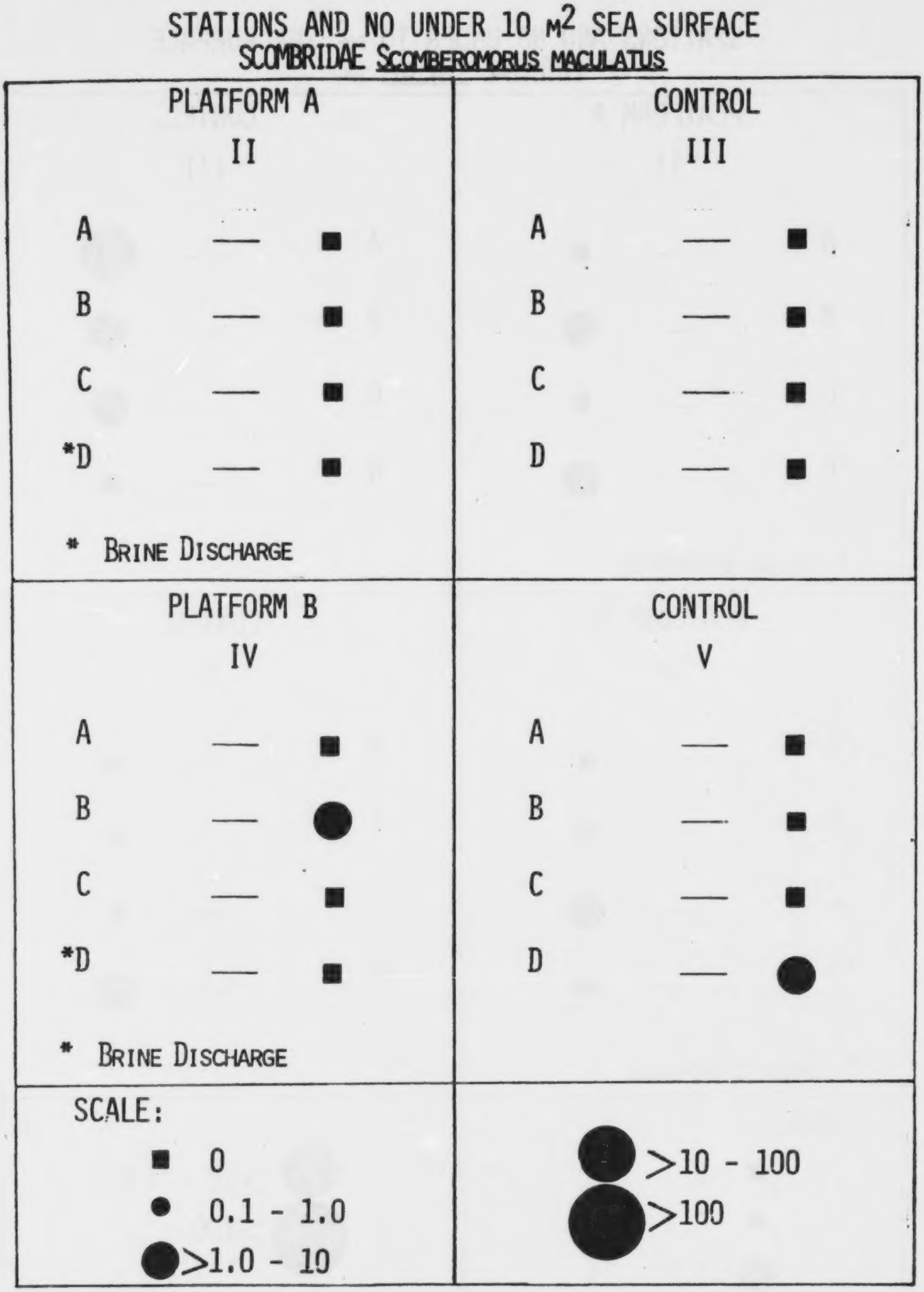

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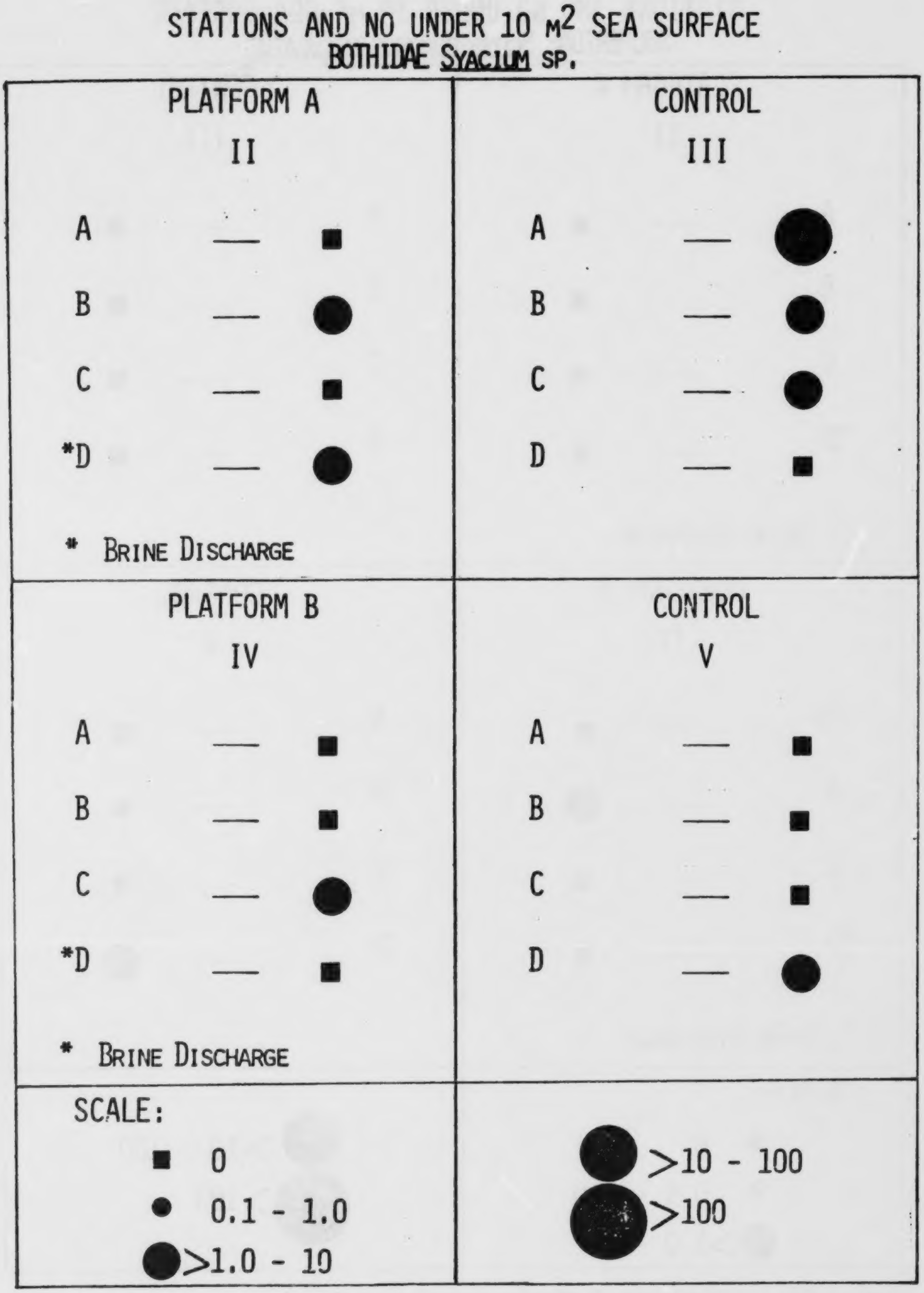

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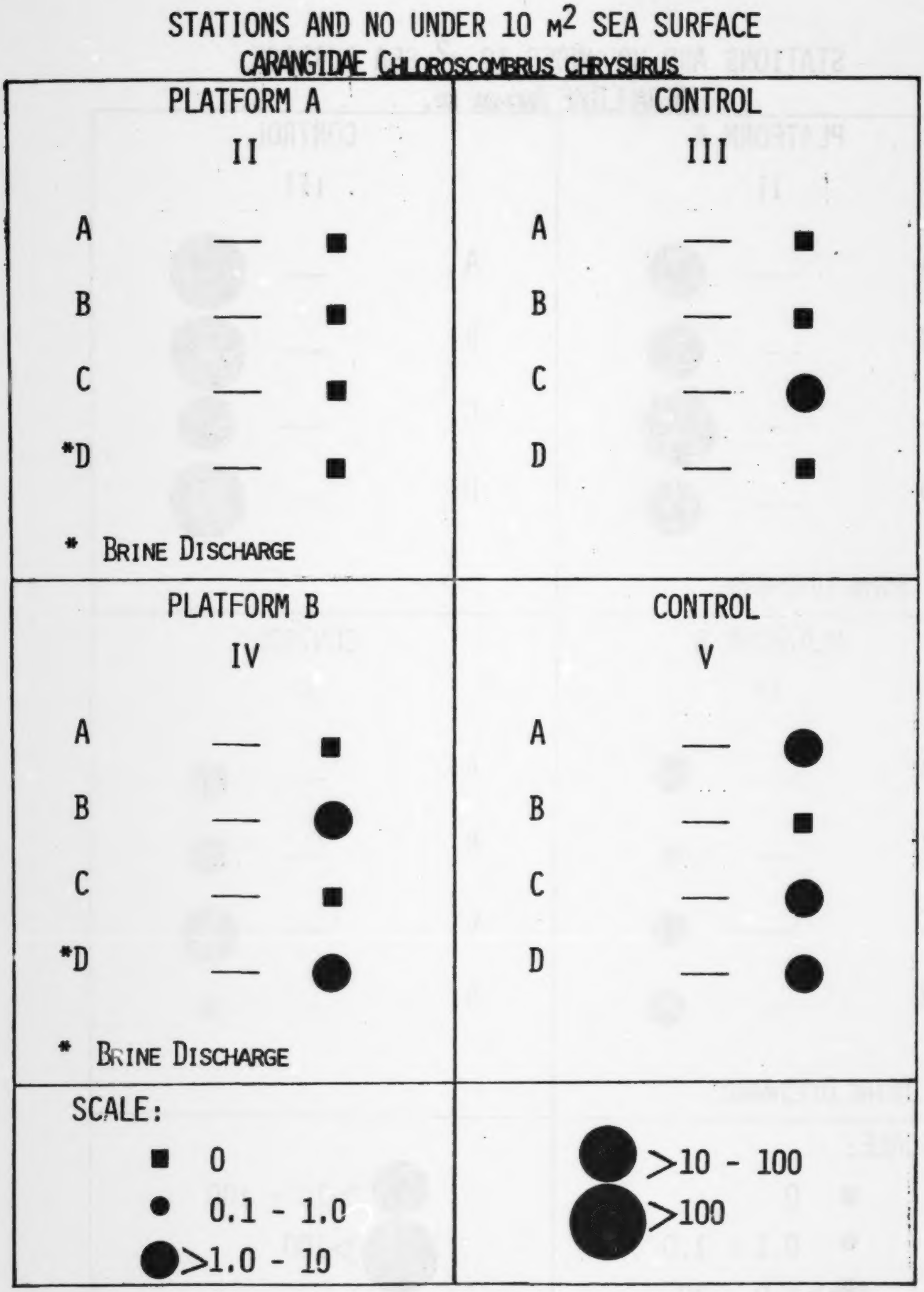

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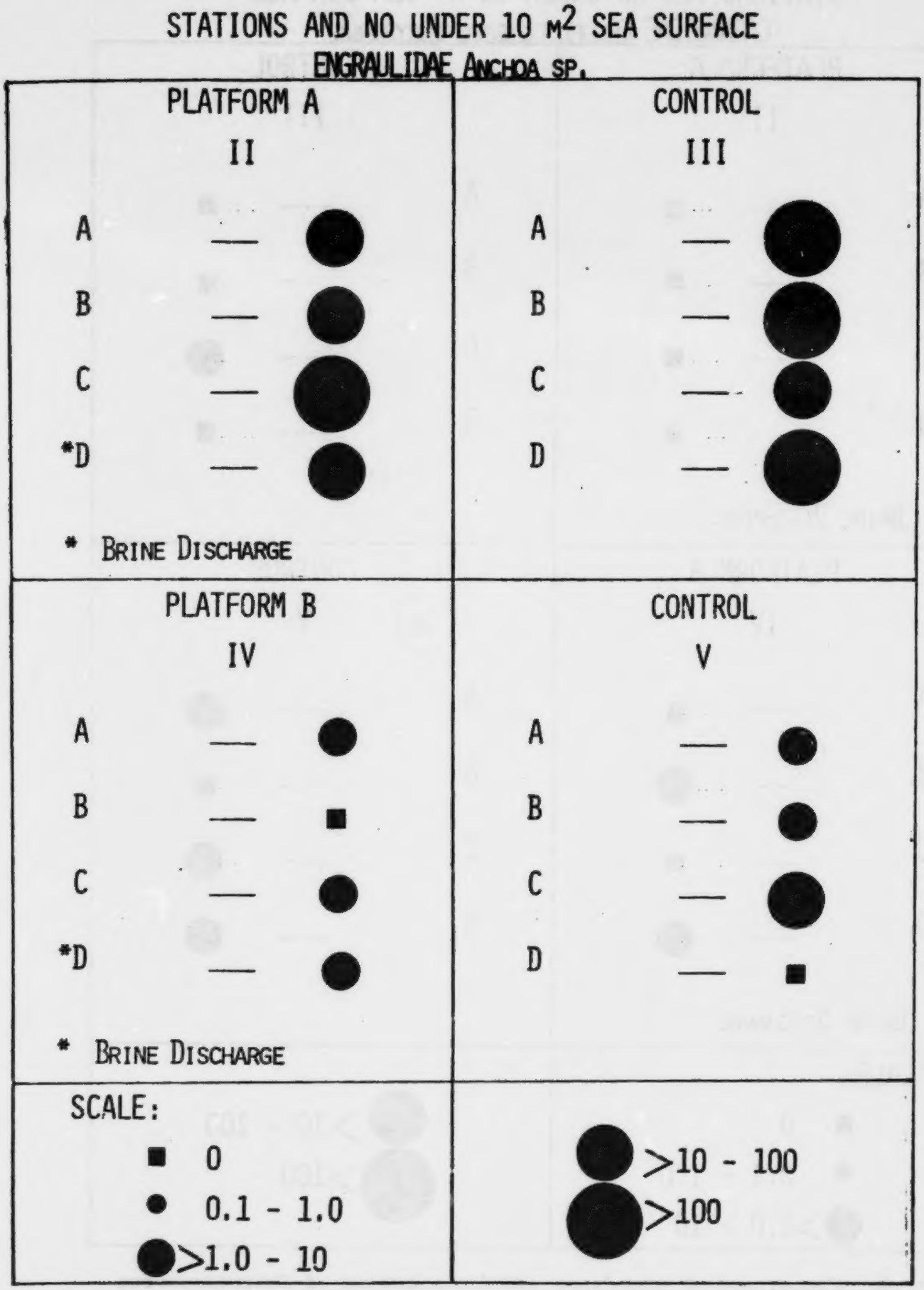

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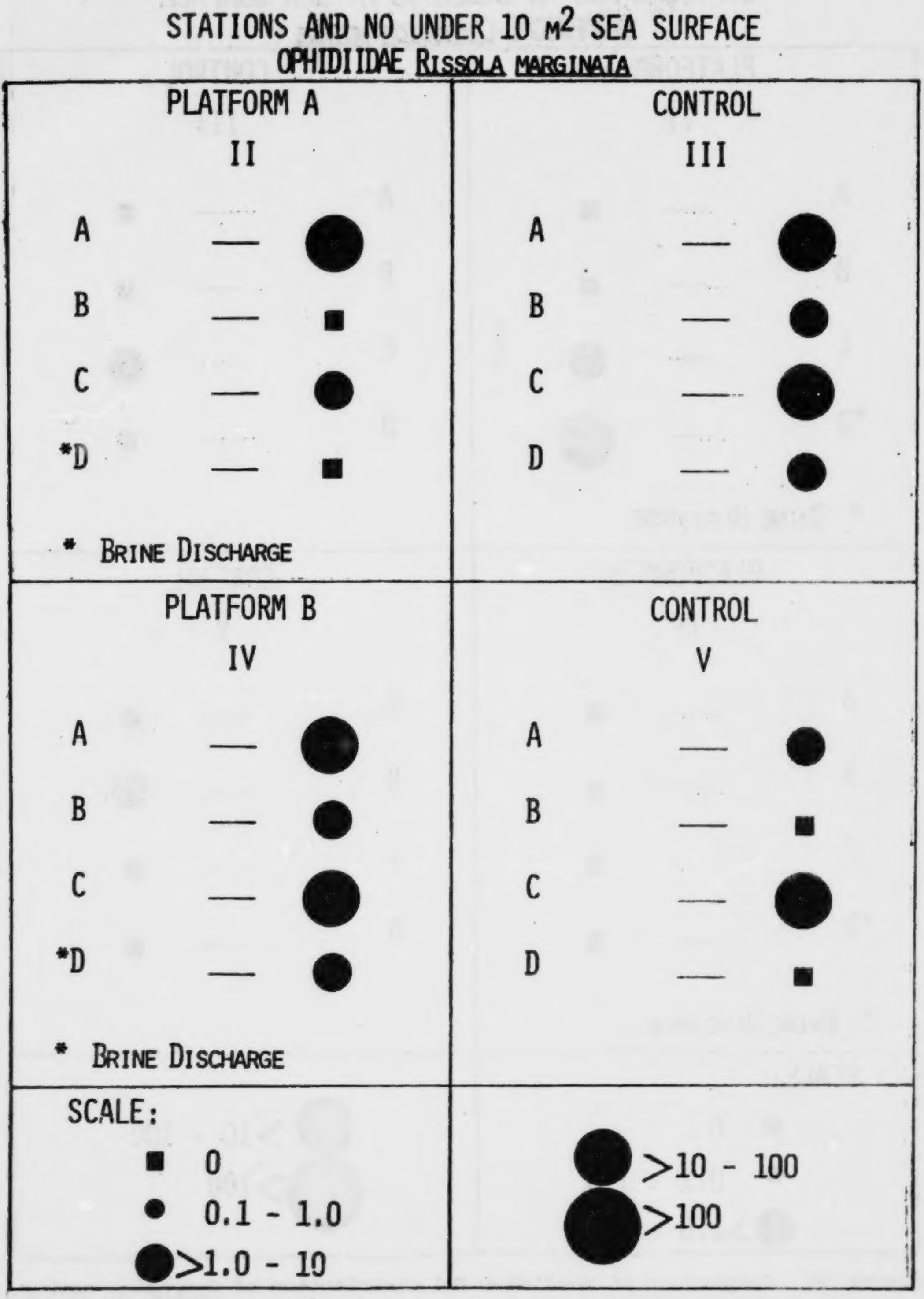

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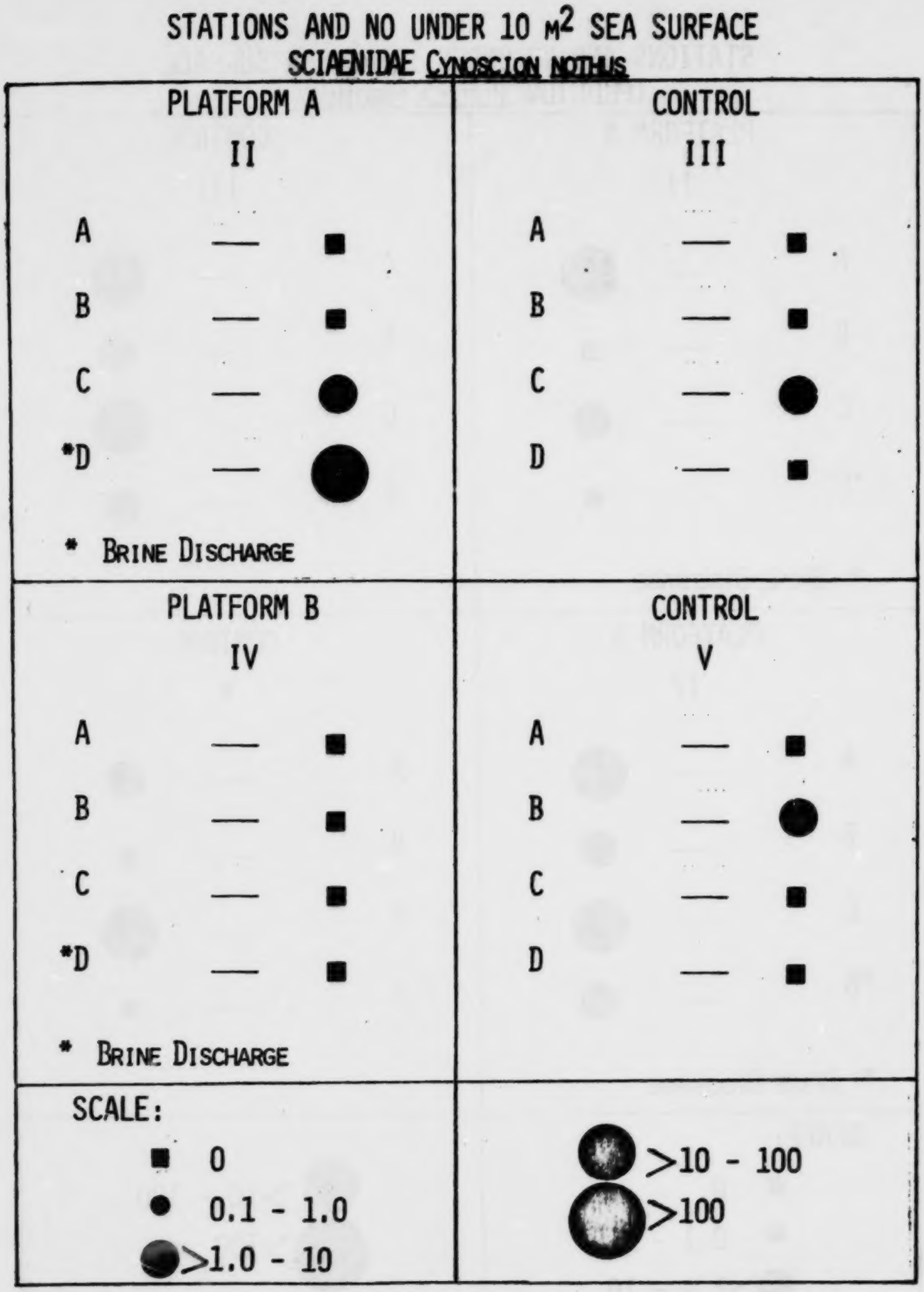

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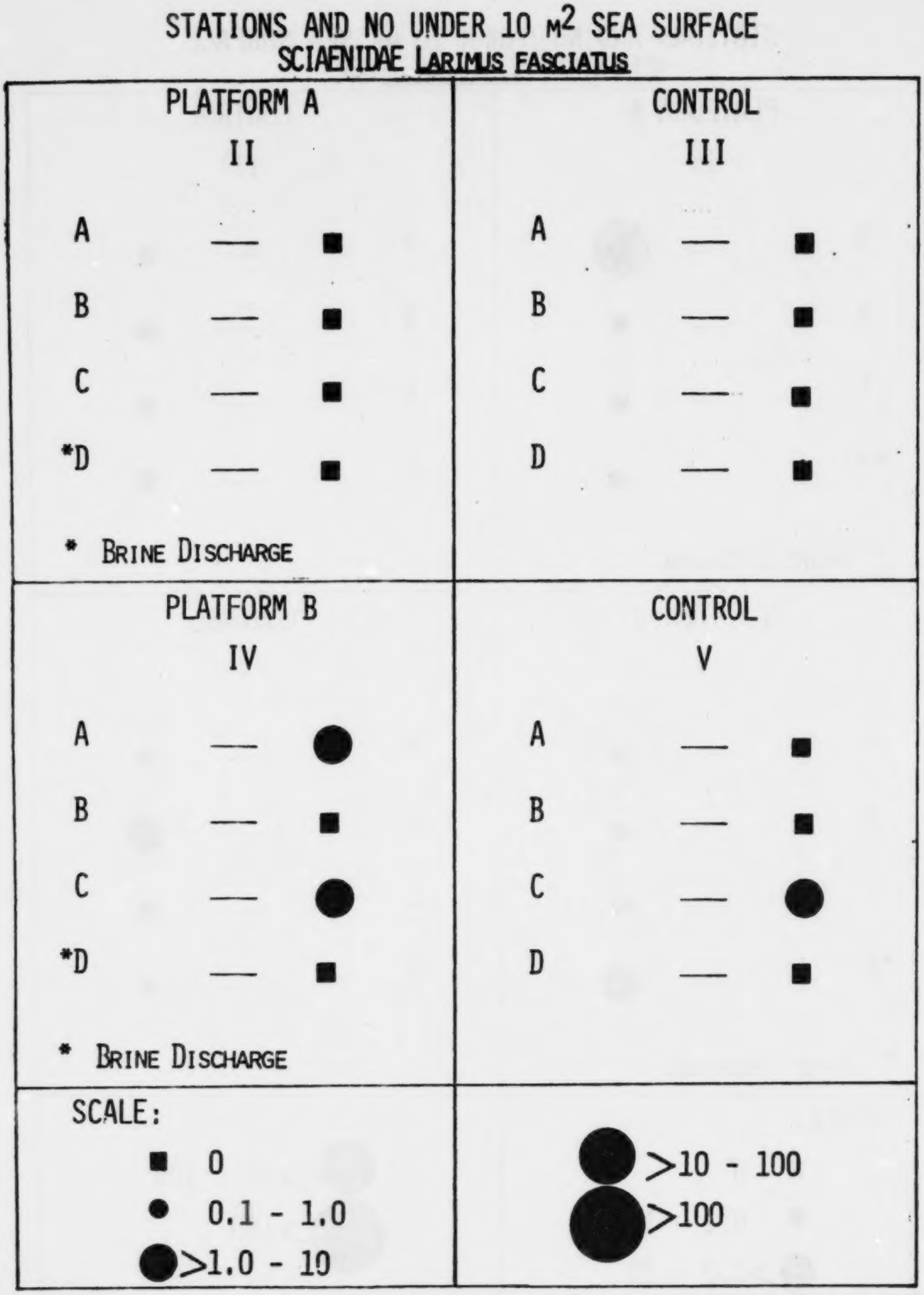

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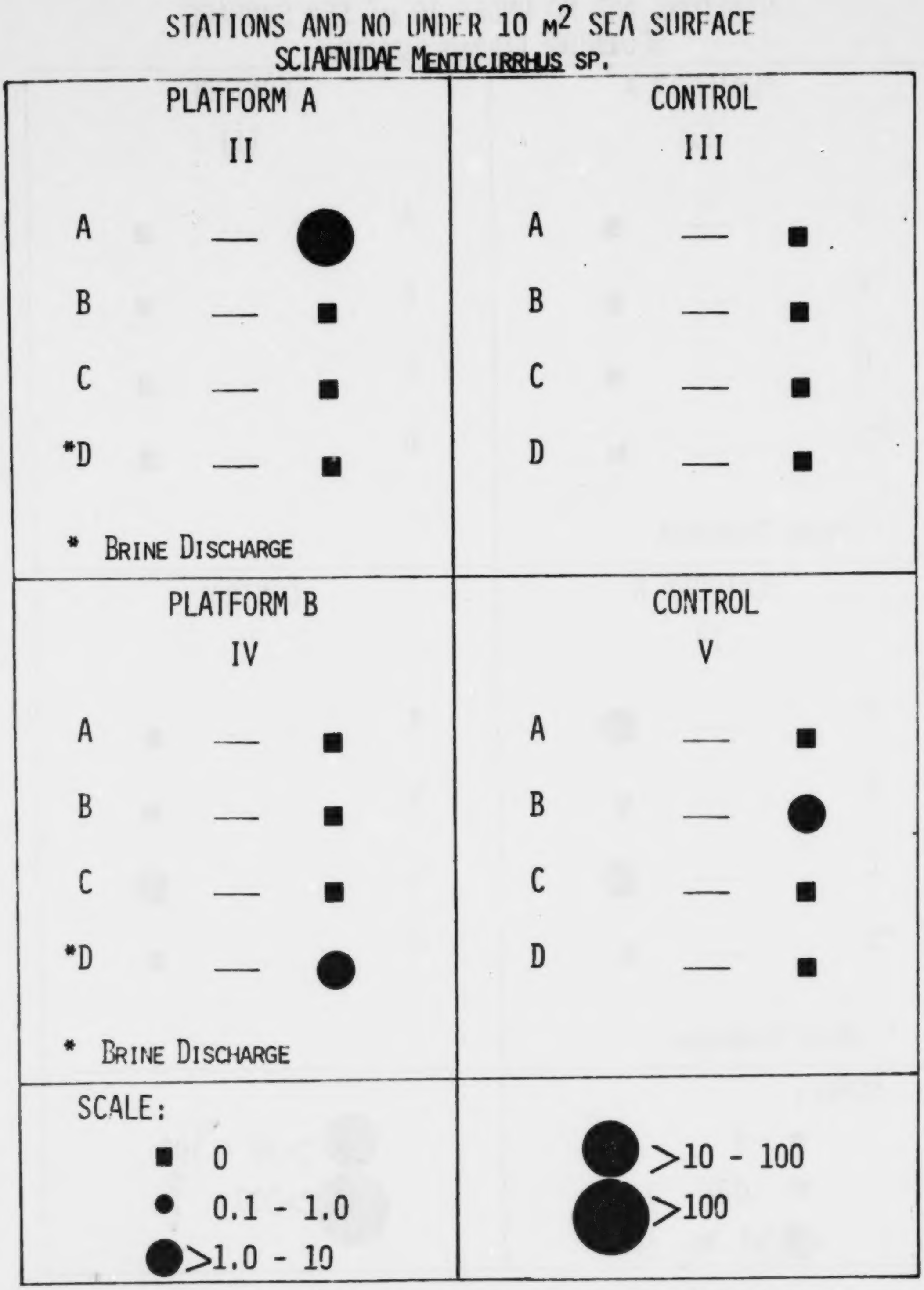

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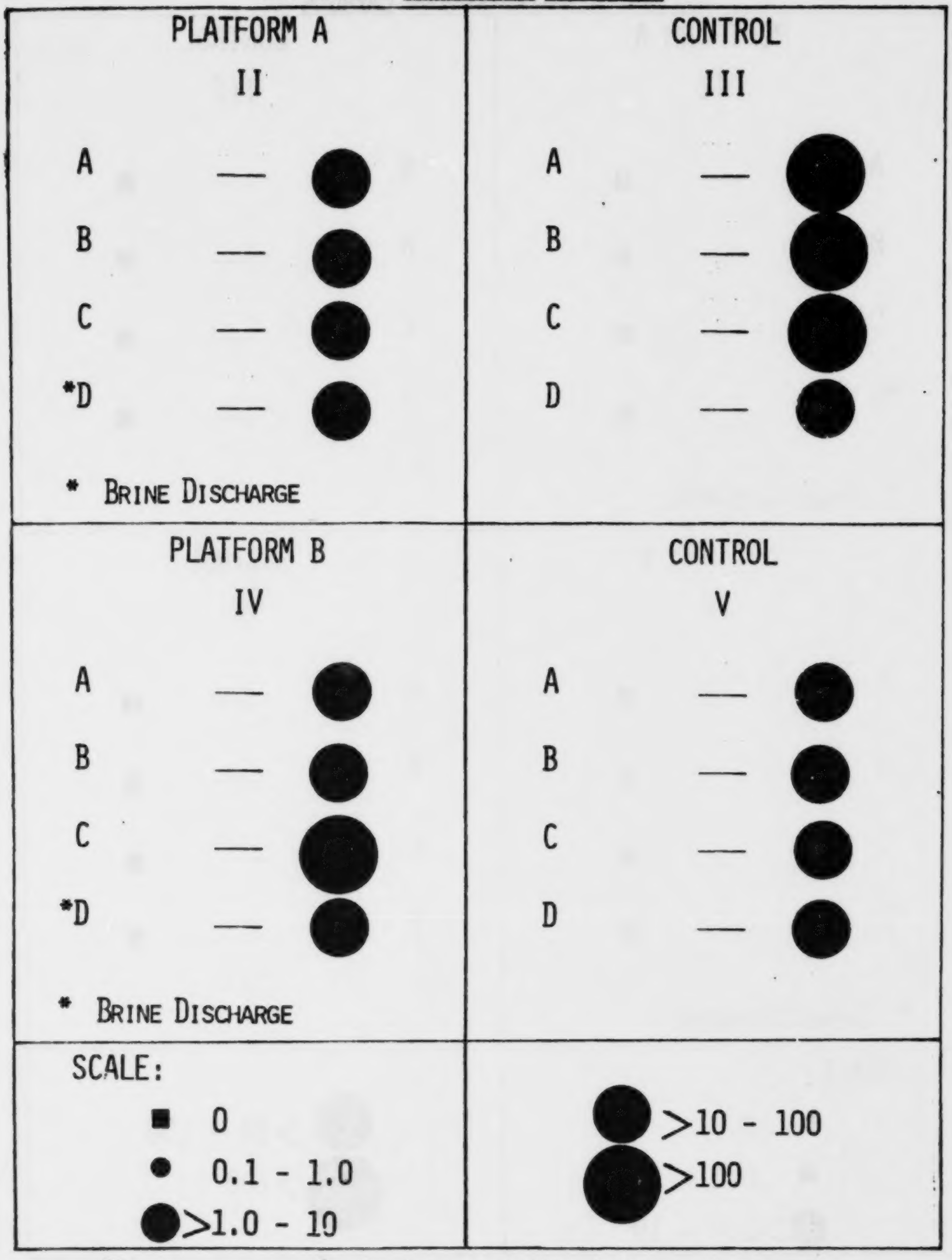
STATIONS AND NO UNDER 10 M^2 SEA SURFACE
SCIAENIDAE *Micropogon undulatus*



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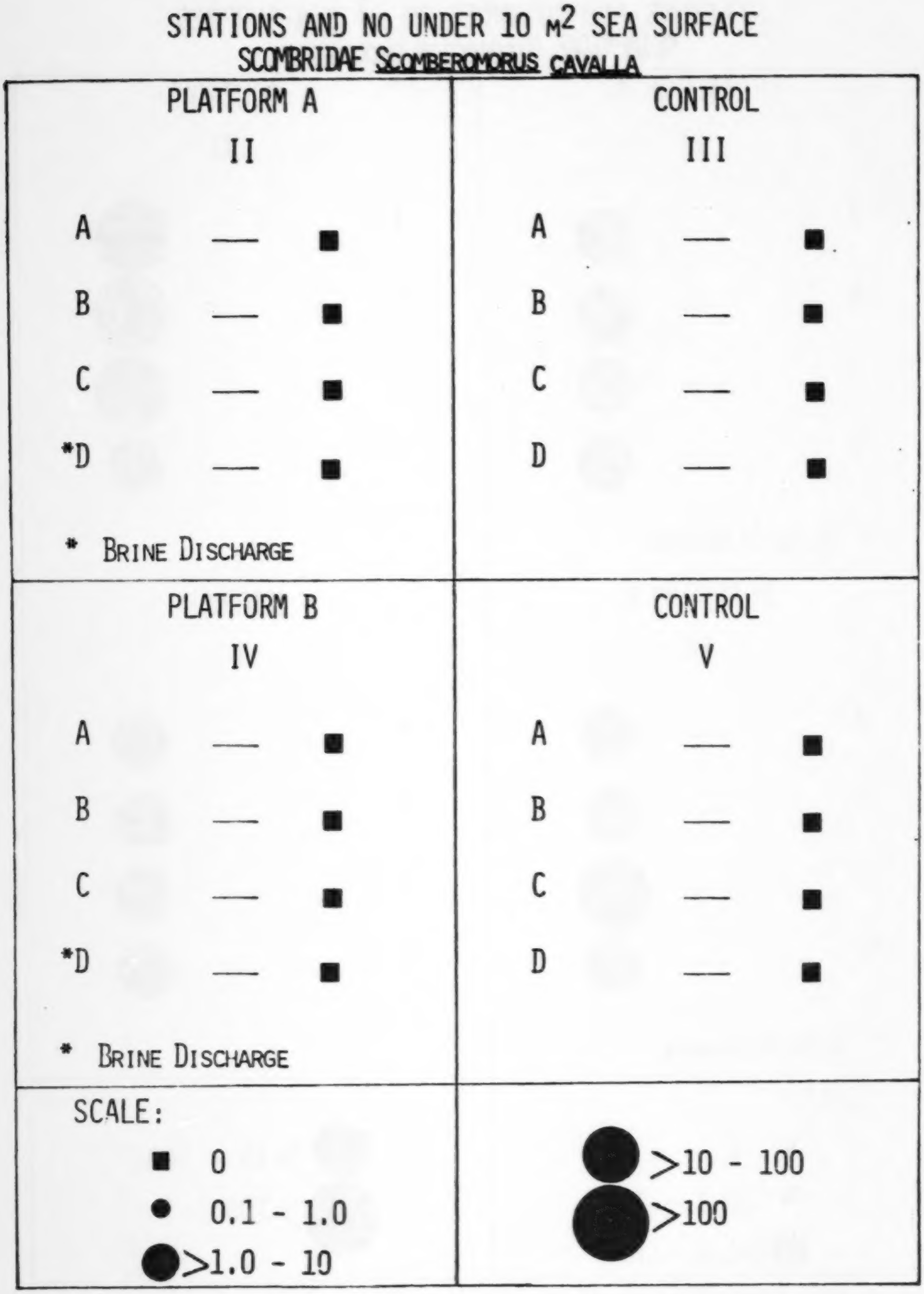

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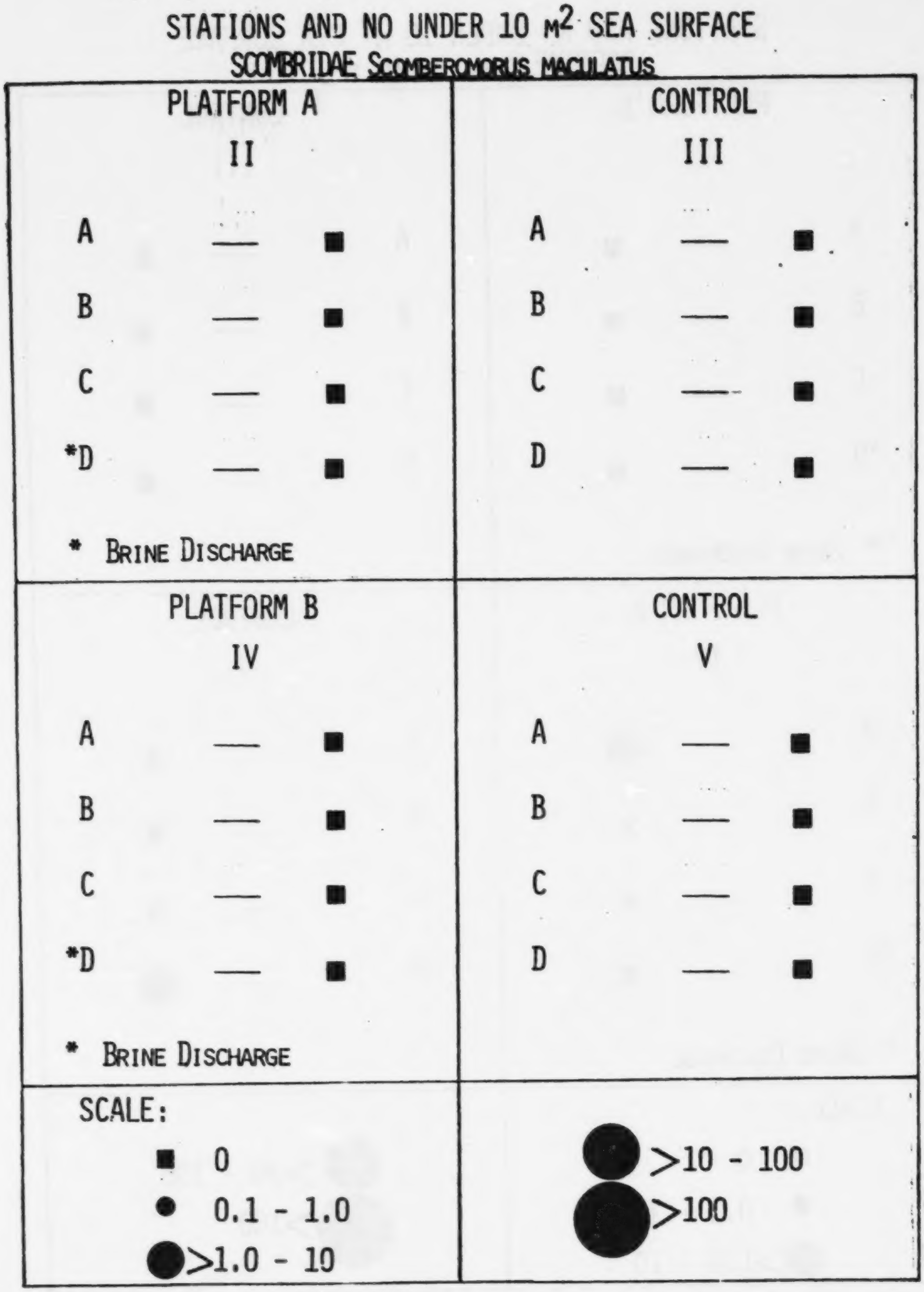

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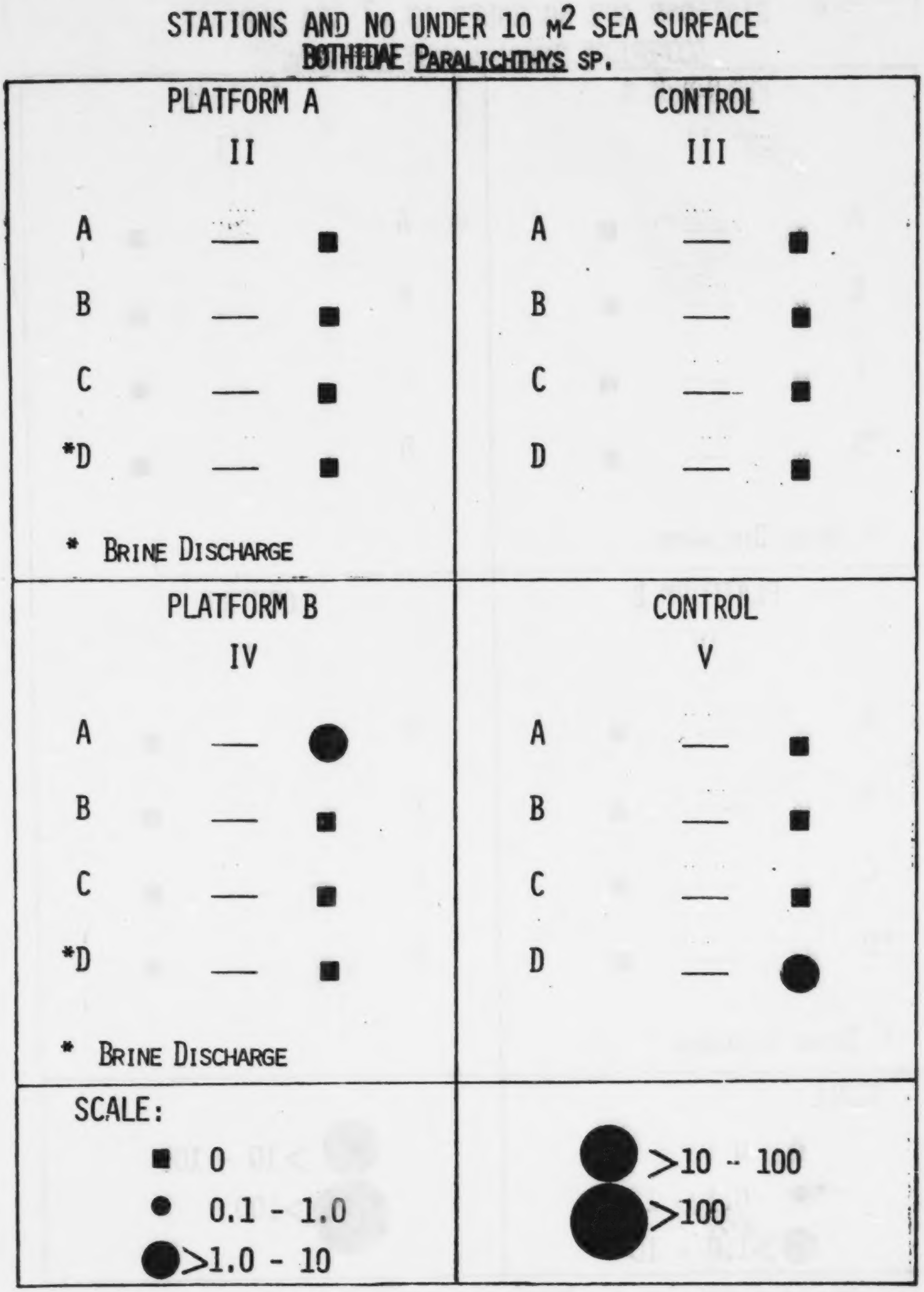

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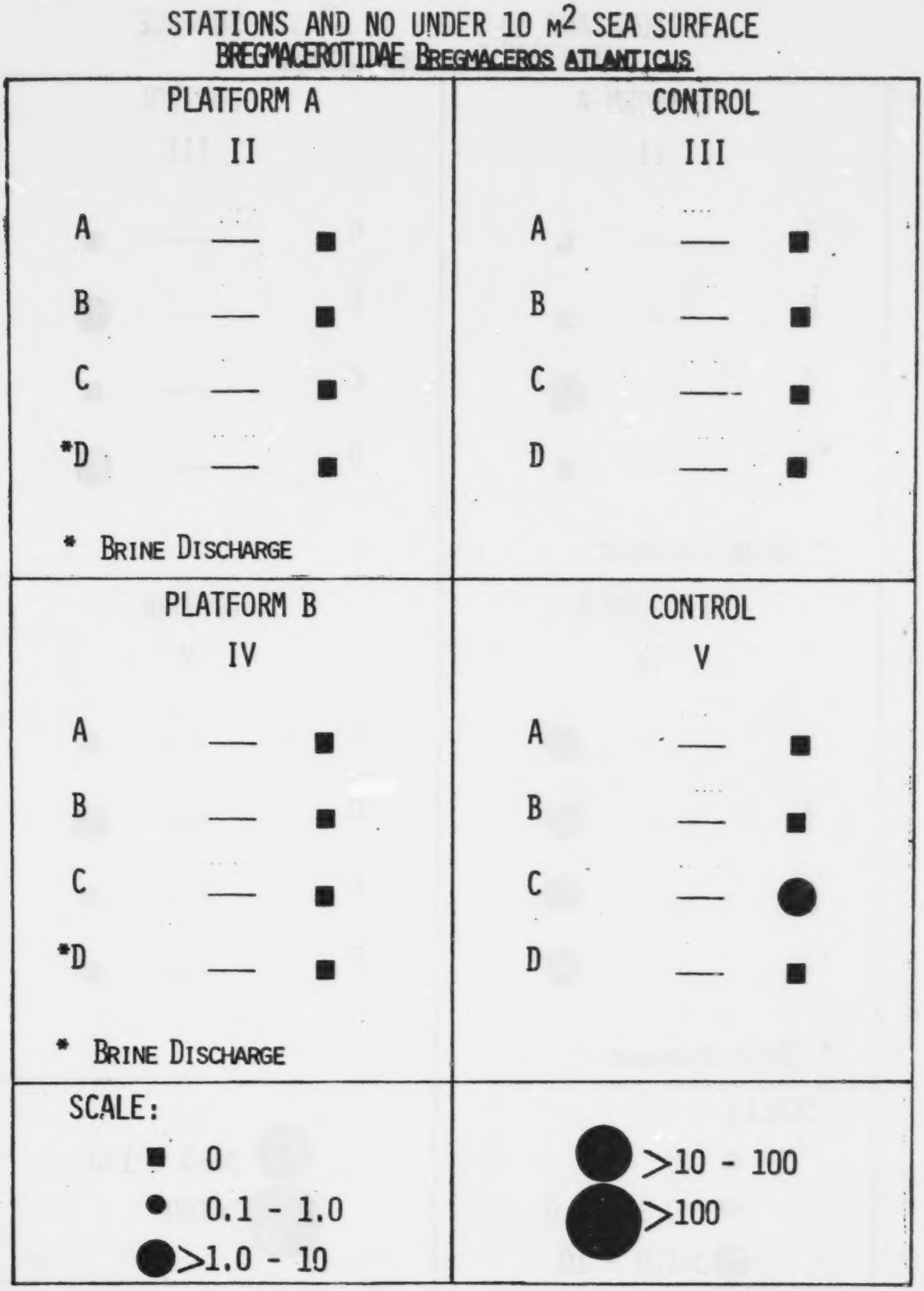

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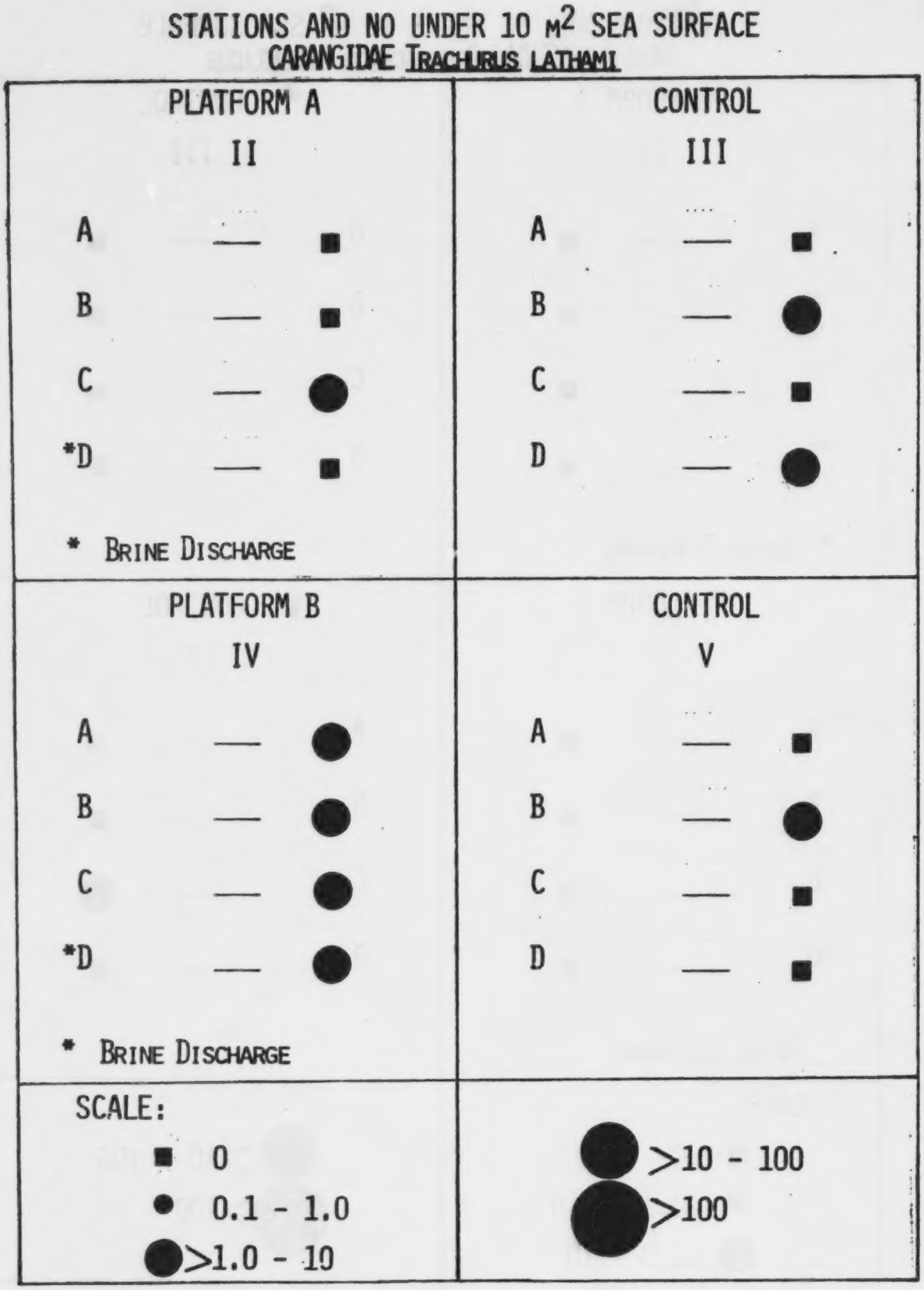

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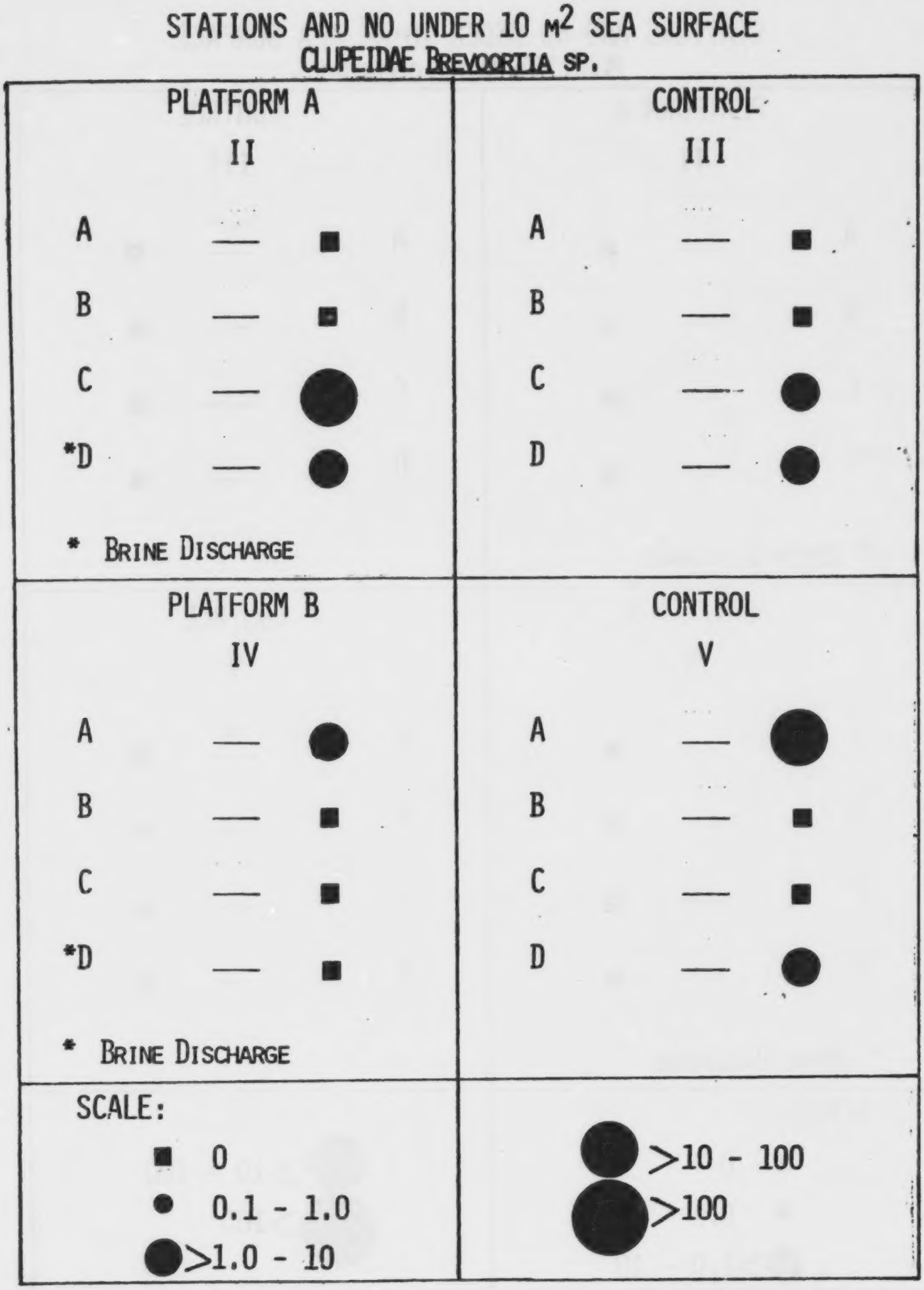

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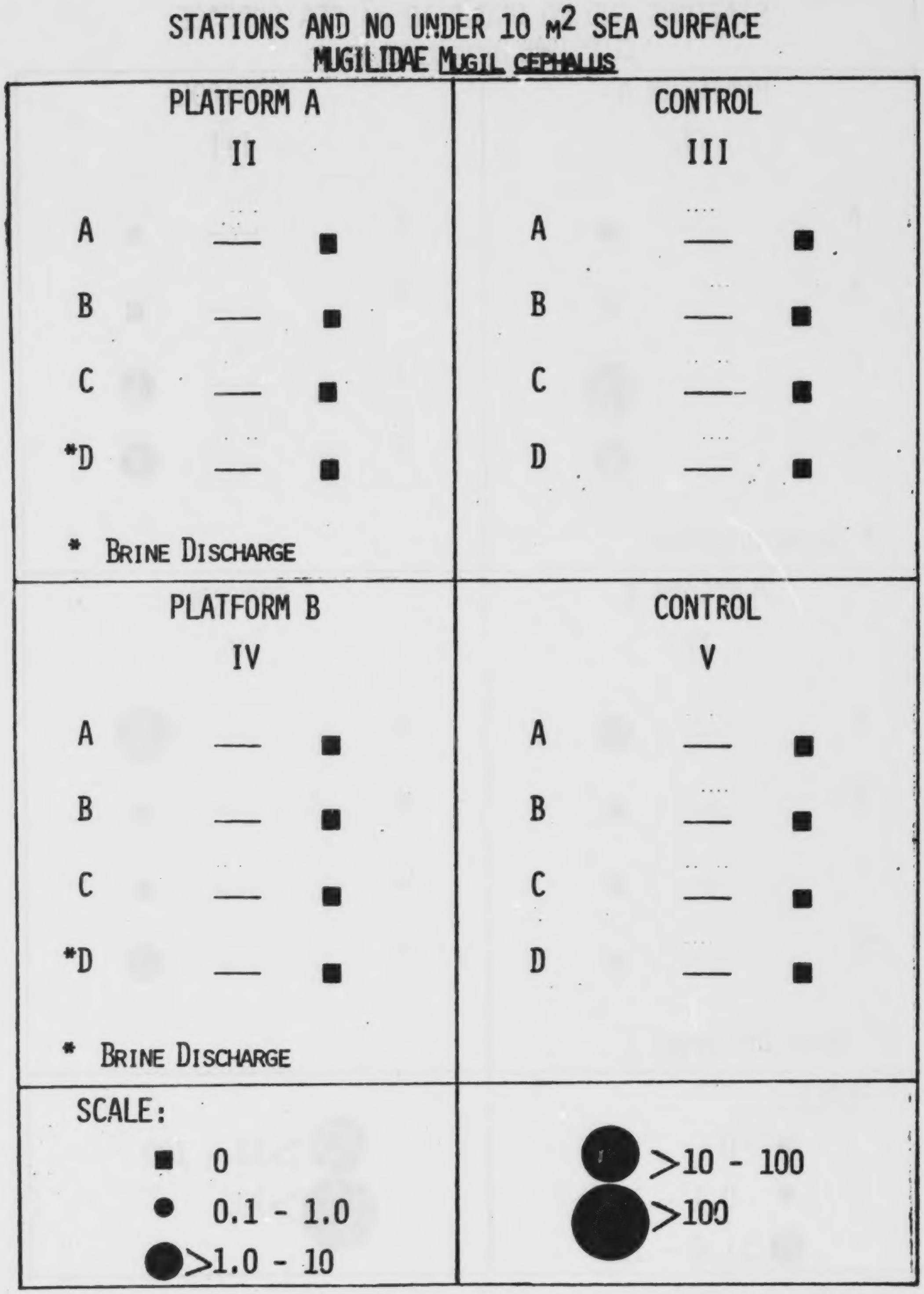

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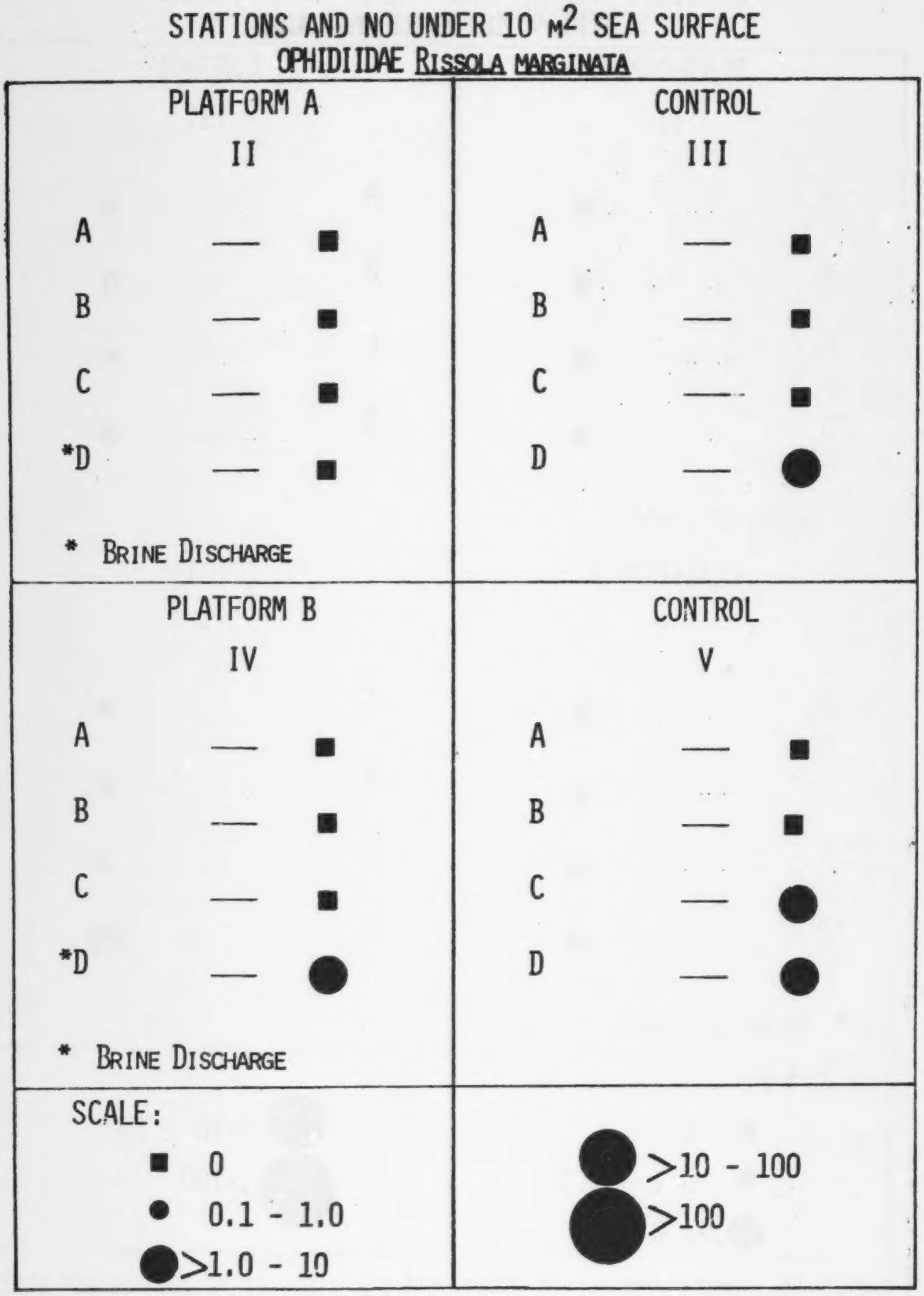

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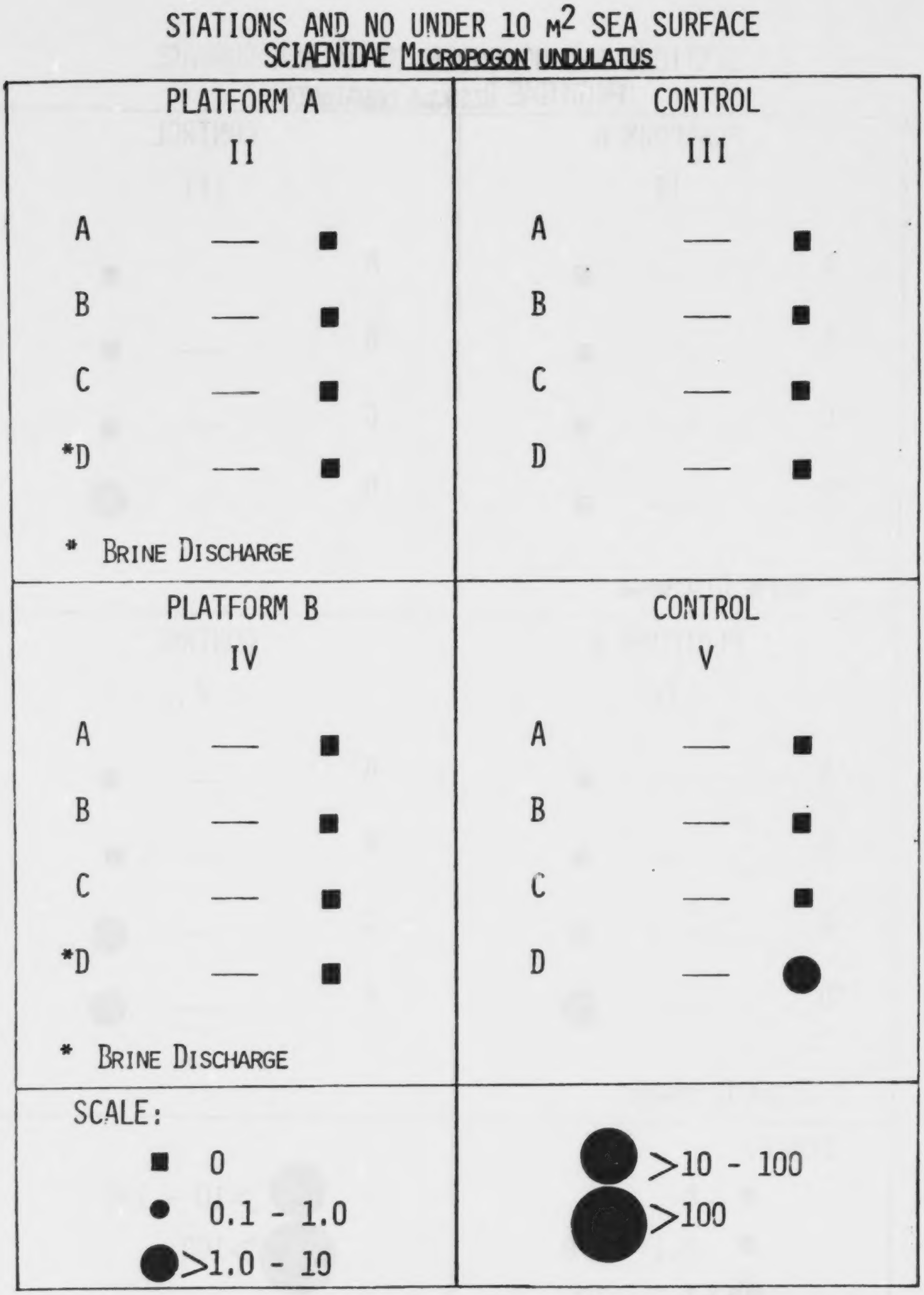

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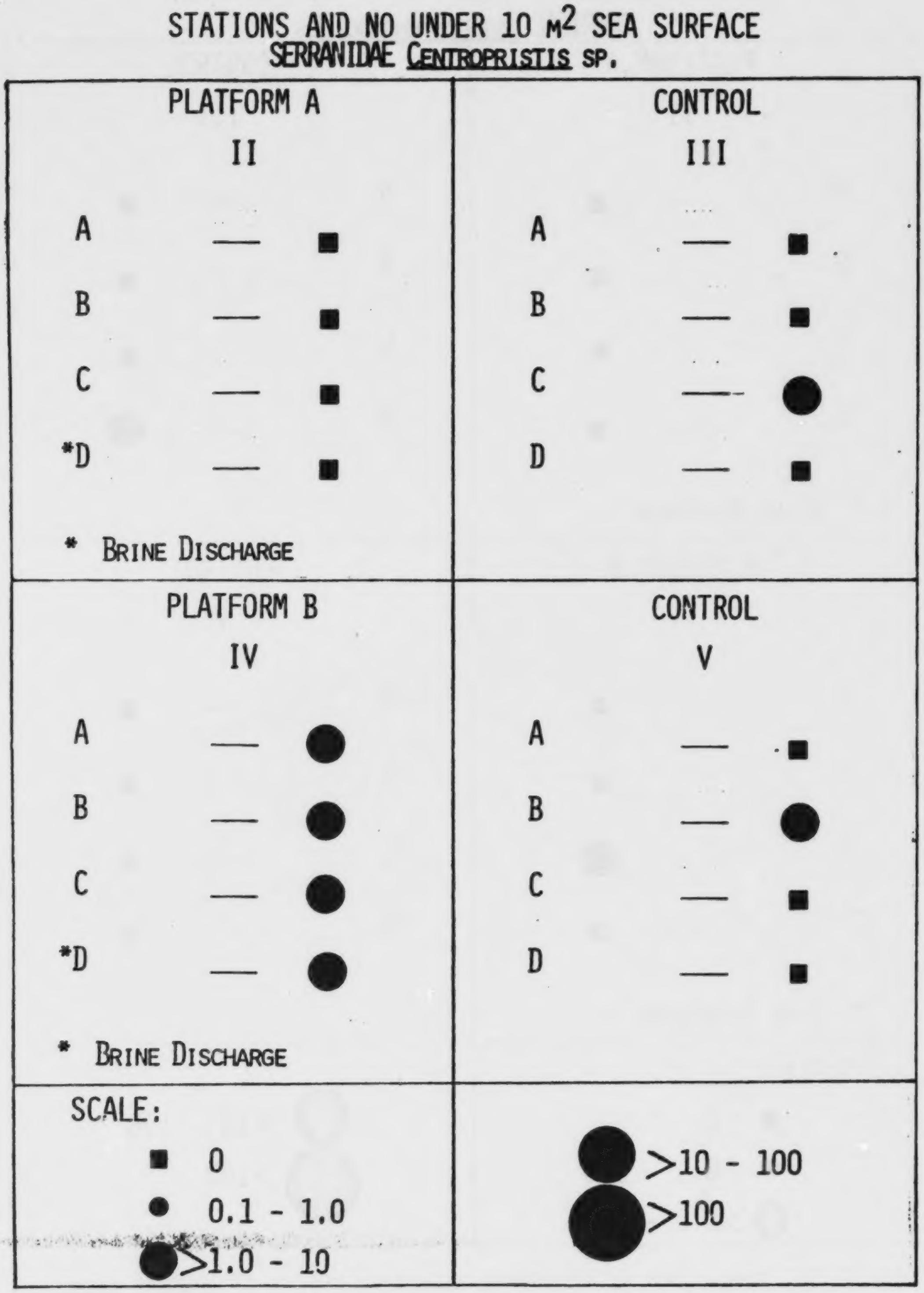

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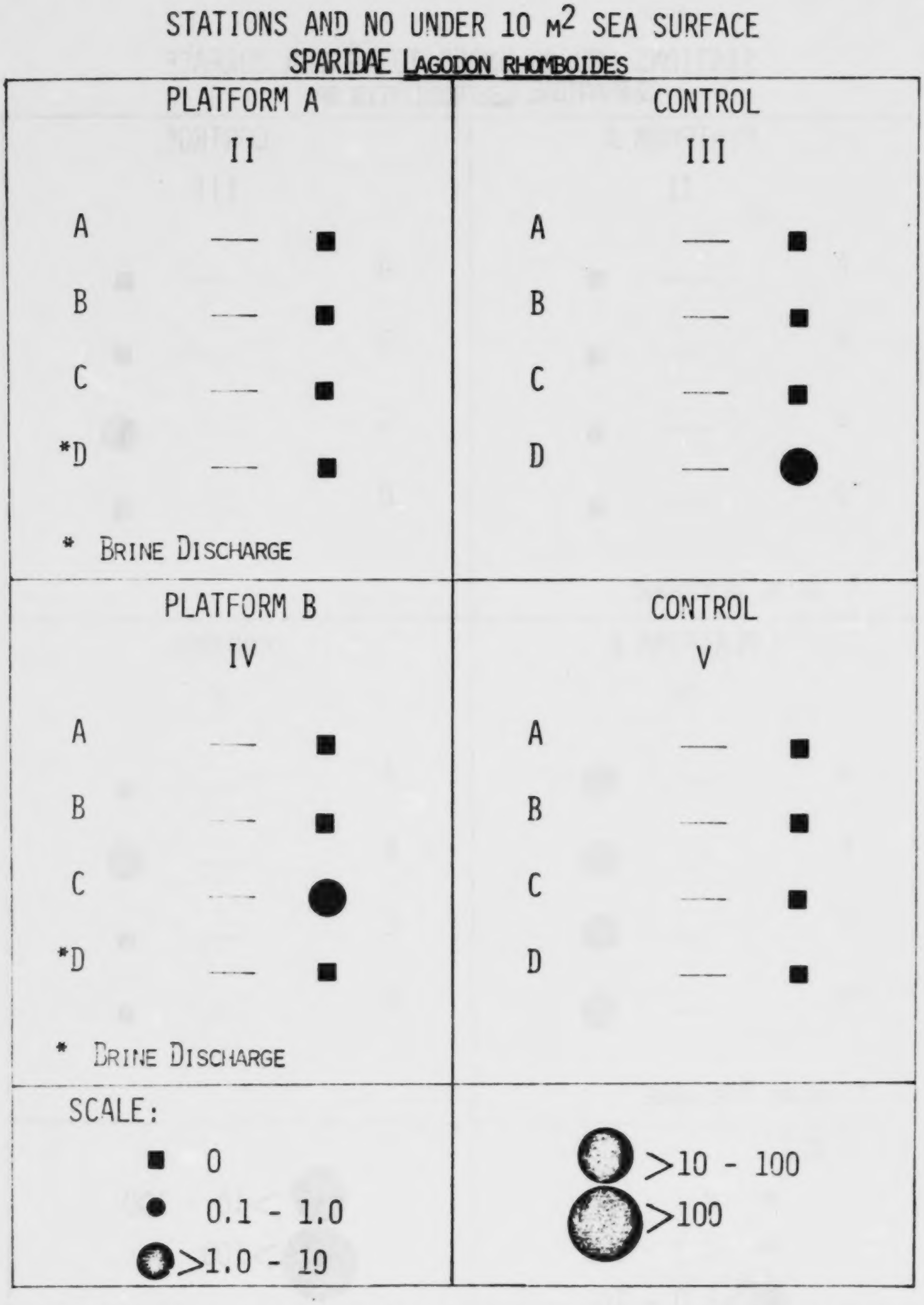

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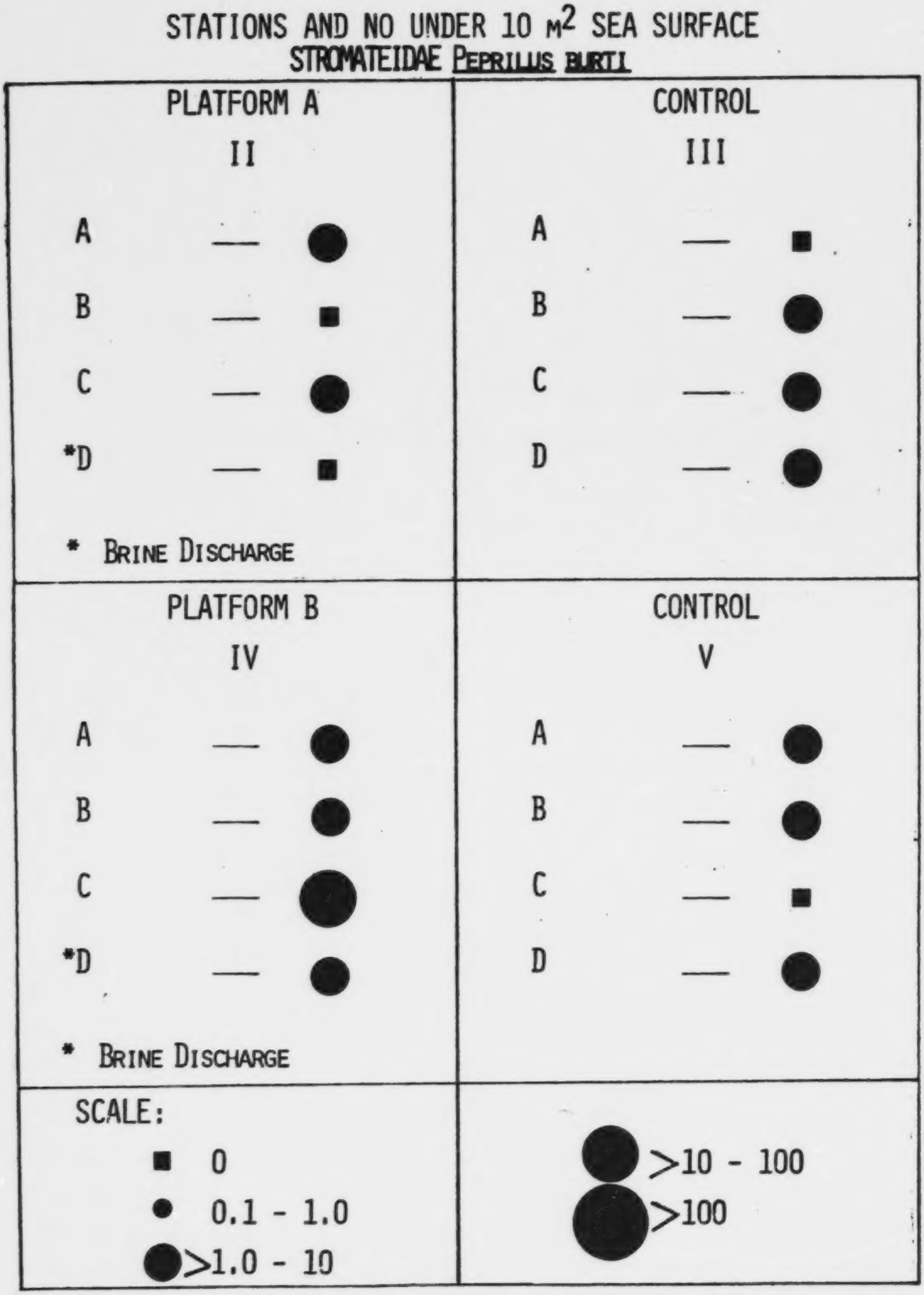

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Work Unit 2.3.7 Determine and Compare Groups of Bacteria From an Active Oil Field and Unaltered Area

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S. L. Hollaway

G. M. Faw

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Abstract

An intensive one year study of the bacterial population of the Buccaneer oil field was undertaken. The taxonomic composition, distribution and physiological profile of bacteria from the oil field were compared to microorganisms collected from a control site. As expected, more oil-degrading and sulfur-oxidizing bacteria were found near the petroleum production platform than in the control area. Pseudomonas organisms were the most common bacteria in both the oil field and the control site. Other genera found included Vibrio, Aeromonas, Moraxella, and Acinetobacter. There was no noticeable difference in the genera found at different sampling sites.

In general, diluted Buccaneer brine discharge did not adversely affect bacteria. Isolates collected from near the platform were able to grow in the presence of the petroleum products and exhibit normal bacterial attachment to glass surfaces. Bacterial chemotaxis in certain test strains was affected by Buccaneer brine discharge. Some strains appeared to be attracted toward brine discharge while others either were repelled by the discharge or exhibited reduced chemotaxis in the presence of the discharge. An attempt was made to measure the potential bacterial biodegradation of Buccaneer field hydrocarbons. In laboratory conditions, mixed culture inocula showed little, if any, hydrocarbon degradation. Often, the loss of hydrocarbons through abiotic weathering was much greater than the loss from biodegradation. Certain pure cultures were isolated from the study area which could readily attack at least the "alkane" fraction of Buccaneer hydrocarbons. One strain was shown to be able to utilize approximately 50% of the alkane in a seven day period which combined with the abiotic weathering, resulted in a net loss of about 80% of the alkane fraction in seven days.

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Introduction

Microorganisms, particularly bacteria, constitute the largest numerical population in most aquatic environments and are often the most metabolically active aquatic organisms. The short generation time and great physiological capacity of bacteria as a group enable them to survive and flourish in environments that are inhospitable to other organisms. Indeed, bacterial activity can alter an aquatic environment, thereby affecting the ability of the environment to maintain nonmicrobial populations. Often bacterial activity renders recalcitrant materials more palatable or less noxious, thus improving the environment for other organisms. Petroleum, in general, represents a form of organic pollution that may have adverse effects on aquatic habitats. In the marine environment, microorganisms are the major biotic factors responsible for recycling petroleum (LaRock and Severance, 1973; Walker and Colwell, 1974). Therefore, any comprehensive study of the effects of petroleum on the aquatic biosphere should include a study of bacterial adaptation to petroleum pollution.

Petroleum and associated pollutants have a number of effects on the microbial population. Components of oil are recalcitrant and may be inhibitory to some portions of the bacterial population (Atlas, 1975; Walker and Colwell, 1975 a.) One of the objectives of this study was to determine the effects of oil pollutants on the normal bacterial population of uncontaminated sites and to estimate the success of the microbial population around the production platforms to cope with the petroleums.

Microorganisms are not passive individuals which merely respond to habitat changes, but are actively altering the aquatic environment. Estimations of the rate of attack on petroleum products by bacteria combined with an appreciation of the by-products resulting from microbial degradation are vital to determine the effect of oil pollution in the marine environment. This information can be used to estimate the fate of petroleum products in the ocean and thus, is vital in assessing the impact of oil field contaminants. To date, bacteriologists have concentrated a large portion of their studies on unexpected large oil spills occurring near coastlines. These acutely oil-polluted sites have been found to support relatively large bacterial populations containing an abnormally high proportion of bacteria capable of degrading oil. Production platforms in the Gulf of Mexico afford a unique opportunity to study the microbial ecology of oil degradation because they represent an area of long-term exposure to low levels of oil pollutants. These sites of chronic oil contamination may be the most severely damaged environments (Loughry, 1977), but the autochthonous bacterial population of these areas has had a maximal opportunity to adapt to the presence of the platform. This study was designed to determine the extent of microbial adaptation around the oil drilling site.

The specific objectives of this first year's study were (1) to estimate the number of various types of bacteria in the field as opposed to the control site; (2) to determine the taxonomic makeup of the study area and the control site; (3) to examine the effect of Buccaneer field products on bacteria growth, chemotaxis, and attachment; and (4) to estimate the bacterial degradation potential for Buccaneer hydrocarbons.

Materials and Methods

Sampling

Samples were collected during four cruises (two during the summer, and one each from the spring and winter seasons). One of the summer sampling cruises was in addition to the three contracted cruises and was designed as a training cruise. Most, but not all, bacterial analysis was conducted on this non-contract cruise and is included in this report. A Fifth cruise was added to the sampling regime to permit collection of a number of samples very close to the production platform. This cruise which will be referred to in this report as the intensive sampling period was carried out October 12 and 13 in concert with other principal investigators. The normal sampling patterns (Figure 1) called for collecting samples from immediately under production platforms 288-A and 288-B and from sites at intervals (one nautical mile, and two nautical miles) on a line south by southwest of the respective platforms. A control site which was five miles due north of the oil field was routinely sampled. Water samples were collected with a Niskin sterile bag sampler at a mid-water depth and from a depth approximately one to two meters above the bottom. Surface water samples were collected with a sterile glass bottle. Surface sediment samples were routinely collected with a Petite Ponar Grab. During the intensive sampling period, surface sediment samples were collected by divers using sterile glass jars. Samples during the intensive sampling period were collected on an east-west line at production platform 288-A and a satellite platform 288-B which served as the control site. Divers estimated distance from the platform and collected sediment from immediately below platforms and at 25 foot intervals up to 100 feet. Sediment from 0, 50, and 100 feet were routinely analyzed. The 25 foot and 75 foot samples were also examined for certain tract lines.

Enumeration

All samples were plated in the field as soon as possible after collection. Shipboard plating was routinely used with the exception of the intensive sampling period. During this sampling period, a technician was stationed on the platform and samples were plated immediately after they were brought to the surface by divers.

Total viable counts (TVC) were obtained utilizing a spread plate technic with Modified Sea Water Yeast Extract (MSWYE) agar (for composition of media used in this study, see Table 1). Sediment samples were diluted before plating using sterile 9 ml MSWYE broth dilution blanks.

All plates were done in triplicate (on some cruises, five replicate plates were used) and counts were given as the average of the three plate counts. Plates were incubated at 25°C and were counted after two and seven days. These plates were also used to collect strains for taxonomic analysis. The highest counts from either the two or seven day incubation were used to estimate the total viable counts. The biomass estimate was calculated by multiplying the total viable counts by the average cell volumes estimated from submerged slide experiments. The submerged slide experiments were conducted by using chromic acid cleaned glass cover slips which were submerged at the sampling site from two to twenty-four hours. The slides were rinsed with sterile 3 salts solution, fixed and stained before microscopic examination. A minimum of a hundred bacteria from each slide was examined and their cell volume was estimated using a microscope micrometer. No more than ten bacteria from each microscopic field were examined and only one bacteria in a chain of bacteria was counted in the total.

Oil and sulfur-utilizing bacteria were enumerated using a most probable number (MPN) extinction dilution technic. Triplicate tubes of the enumeration broths were inoculated with dilutions of freshly collected samples. Oil MPN were examined for turbidity after twenty-eight days of incubation at 25C. Random samples of the routine tubes were tested by streaking the positive tubes onto either oil silca gel plates or oil agar plates and checking for growth. Sulfur-oxidizing MPN were enumerated by observing the pH change created by the bacterial oxidation of elemental sulfur to sulfuric acid (Postgate, 1967).

Bacteria attached to suspended particulate material was enumerated by using selective filtration followed by spread plate counts on MSWYE agar. Freshly collected 100 ml water samples were filtered through sterile plankton netting with an average pore size of 50 μ on a sterile filter apparatus. The water which passed through the filter was collected in a sterile glass container and the bacteria were enumerated. The particulate material trapped on the filter was washed off by inverting the filter and flushing the filter with 100 ml of sterile 3 salts solution. The resulting solution was collected in a sterile container and blended in a sterile blender to remove any bacteria attached to the resuspended particulate material. The resulting solution was plated on MSWYE agar and the bacteria enumerated. To check the validity and precision of the filtration system, the counts of the bacteria trapped on the filter and passing through the filter were added and the sum compared to the total viable counts of untreated samples collected at the same time.

During cruise #2, water samples were enumerated for the presence of bacteria resistant to heavy metals. The two heavy metals used were zinc and chromium. Heavy metal resistance was checked for by simply plating samples onto MSWYE agar prepared with appropriate concentrations (100 ppm) of the heavy metals in the media. The resistant bacteria were plated, incubated, and counted the same as the TVC organisms.

Anaerobic sulfur metabolism was examined during the intensive sampling period. A hundred bacteria from each of the samples were examined for the production of hydrogen sulfide. Kliger Iron Agar (KIA prepared with 3 salts solution) was inoculated with a colony from the plates used for the total viable counts and hydrogen sulfide production was detected by blackening of the media. The other taxonomic characteristics exhibited by the colonies on the KIA media were also recorded.

Bacterial Behavior

Three types of bacterial activity were checked in the presence of hydrocarbons from the oil field. These three responses: toxicity, chemotaxis, and attachment, were loosely grouped under the category of bacterial behavior.

The growth of mixed and pure bacterial cultures was checked in the presence and absence of hydrocarbons from the production platforms. The mixed culture inocula used were either freshly collected water or diluted sediment. Pure cultures of organisms isolated from the field or strains of laboratory cultures were also utilized. Either diluted sterile Buccaneer condensate (collected from the Shell refinery in Freeport, Texas) or diluted sterile brine discharge collected from the Buccaneer production platforms were added to a sterile salt solution. The dilutions of condensate and discharge were designed to simulate the conditions around a spill of either component. The dilute materials were inoculated with the bacterial cultures. The growth mixtures were incubated with shaking at room temperature for various periods of time. At intervals, the bacteria were enumerated using either total viable counts or spectrophotometry.

Bacteria chemotactic responses were also checked in the presence of Buccaneer hydrocarbon products. Chemotactic experiments were conducted by filling capillary pipets with sterile solutions of various suspected repellants or attractants and placing the pipets in various bacterial solutions. If the bacteria are attracted to the solution in the capillary pipets, the bacterial numbers will increase in the pipet. Pipets containing sterile salt solutions were used as a control and any number above or below the bacterial number in the control pipet was counted as either repellant or attractant. Among the compounds tested for their ability to elicit chemotactic response include arginine, glucose, distilled water, Buccaneer crude oil, and Buccaneer brine discharge. Furthermore, the bacterial cultures were checked for their chemotactic responses toward potential attractants when suspended in Buccaneer field hydrocarbons (either as diluted condensate or diluted brine discharge).

The ability of bacteria to attach to glass surfaces was checked in the presence or absence of Buccaneer hydrocarbons. Acid cleaned glass microscope cover slips were submerged in diluted bacteria cultures which contained salt solution +/- either diluted Buccaneer condensate or Buccaneer brine discharge. After a brief exposure to the bacterial suspensions, the glass slides were removed and treated in a manner similar to that described for the submerged slide experiments. Bacterial attachment was measured by microscopically enumerating the bacteria on the slide.

Taxonomic and Physiological Diversity

A variety of taxonomic tests were used to identify selected strains to the genus level and to give an idea of their physiological capacity. Strains for identification were selected at random from TVC plates. Ideally plates with a low number of bacteria were used and all bacteria on the plate were tested. Isolates were selected from water and sediment from immediately around the platforms as well as the control area. The bacterial key used is described in Table 2 and is basically a simple dichotomous key designed to identify bacteria to the genera level. The classification of bacteria to genus was deemed sufficient considering the confused state of marine bacterial taxonomy. The taxonomic tests followed standard bacterial techniques with exception that salt solutions were used in making the media.

All the strains identified taxonomically were also checked for the presence of certain exoenzymes enabling them to utilize certain biological polymers. The presence of these enzymes were used to estimate what will be called in this report physiological diversity. The polymers which were used include casein, chitin and Tween 80. Strains were also checked for the ability to grow on media lacking a salt water base which suggests the non-marine origin of the strains.

Degradation Rates

Estimates of the potential for bacteria to utilize Buccaneer discharge hydrocarbons were made using gas chromatographic analysis. Pure and mixed cultures of bacteria were grown in an inorganic salt solution containing dilutions of either sterile brine discharge or sterile Buccaneer condensate. This mixture was shaken in the dark at room temperature for various periods of time. The mixtures were frozen at -20C at the end of the experiment for storage before extraction. Weathering controls were prepared using identical uninoculated mixtures and incubation conditions. These weather controls are designed to measure the abiotic breakdown and volatilization of the hydrocarbons in the mixtures. The amount of bacterial degradation for any time interval was estimated by comparing the inoculated mixture with uninoculated mixture incubated for the same period of time.

Qualitative and quantitative measurements of the hydrocarbons were made using an Antek 300 dual column dual flame ionization detector gas chromatograph equipped with a linear temperature programmer. The extraction, fractionation and concentration techniques used were essentially those proposed by Dr. Brian Middleditch in last year's study of the Buccaneer field. This procedure calls for extraction of the acidified sample using an equal volume of cyclohexane. The sample is then fractionated into "alkane", "aromatic", and "asphaltene" components using various solvents on a silca gel column. The resulting fractions are concentrated under nitrogen and stored in the dark until gas chromatographic analysis. Deuteriated hydrocarbon standards of known concentration were added to the sample before extraction for use as an internal standard in quantitation. Separation of individual components was accomplished using columns of 1% OV-1 on Supelcoport (100/120 mesh). The chromatograph was programmed for a temperature gradient of 75 to 305C with a rate of increase of 8C per minute. The emphasis in the degradation experiments was on the degradation of the aliphatic alkane components since we are more confident in our identification of these components.

Results

Three seasonal (summer, fall, and winter) sampling cruises were successfully completed. An additional summer cruise initially designed as a training cruise was also very successful, and the data from that cruise is included in this report. The enumeration data obtained during the four cruises are given in Tables 3 - 7. A sample of brine discharge from Platform 288 A was also collected and subjected to bacterial analysis (Table 3). Total viable counts, percentage sulfur-oxidizing, and percentage oil-degrading bacteria were determined for three depths in the water column and a surface sediment sample. Bacterial biomass estimates were made at sampling sites near the production platforms and the control site during each cruise. During the second sampling cruise, bacterial populations were screened for individuals resistant to the heavy metals, zinc and chromium (Table 7).

The enumeration data were examined for gross distribution patterns in the bacterial numbers. Table 8 shows a summary of all the enumeration data obtained from the water column and Table 9 shows similar data for the sediment samples. The data were also arranged so as to compare counts between different depths (Table 10) and between different cruises (Table 11). In addition to examination of total bacterial numbers, a comparison was made between the biomass estimates of the rig sites and control site (Table 12).

Two of the major components released from the production platforms are sulfur and petroleum. Bacteria capable of utilizing these components were enumerated, and Tables 13 and 14 show a summary of these bacteria for all four cruises. A fifth unique sampling cruise was taken to coordinate sampling of the area immediately under platform 288 A with other principal investigators. This cruise was designed to collect samples very close to the platform to determine if the bacterial population was distinctively different from microorganisms a short distance from the rig. Furthermore, since sulfur is thought to precipitate immediately under the brine discharge point, aerobic and anaerobic sulfur-metabolizing bacteria were emphasized. A summary of the data from this intensive sampling cruise is given in Table 15.

A total of twelve separate toxicity (growth) experiments were conducted using nine different mixed inocula, two control microorganisms (E. coli and Pseudomonas aeruginosa), and four isolates collected from the field. The experiments were conducted using either 1% brine discharge +/- Bactron or)0.1% Buccaneer condensate in an inorganic salts medium. An example of a two-day growth experiment using a mixed culture with E. coli acting as control organism is shown in Figure 2. As is illustrated in Figure 2, brine discharge had approximately the same effect regardless of whether it was reported to contain Bactron or not. This was true in the three experiments in which brine discharge containing Bactron was tested. In the majority of the experiments, both mixed cultures and pure cultures of Buccaneer field isolates were able to increase in number when grown in the test mixture containing either brine discharge or Buccaneer condensate. Even the control microorganisms appear to survive in the hydrocarbon solution.

A single, large attachment study was attempted. Mixed cultures, E. coli, and three isolates from the oil field were examined for their ability to attach to a glass surface in the presence of brine discharge (+/- Bactron) as compared to 3 salts solution alone. With the exception of a single organism which was inhibited in its ability to attach in both the presence and absence of Bactron, all the test organisms either show no effect relative to a 3 salts solution control or an increase in their ability to attach.

The results of the chemotaxis experiments were mixed. A typical set of results is shown in Table 16. In this example, *E. coli* appears to exhibit a greater chemotactic response in the absence of brine discharge whereas, at least in the case of arginine, the marine strain exhibited increased chemotactic response in the presence of brine discharge. A total of nine oil field isolates and two control microorganisms (*E. coli* and *Pseudomonas aeruginosa*) were tested for chemotactic responses in the presence of Buccaneer petroleum products. The selected experiments shown in Table 17 demonstrate the variety of results which were generated. For example, *P. aeruginosa* on I-11 appears to move toward the potential attractant only in the presence of the brine discharge. Other strains, such as I-80, appear to be attracted to glucose and arginine in the presence or absence of brine discharge. Some strains, such as D-4 (Table 16), appear to exhibit reduced chemotactic responses in the presence of platform discharge.

Bacterial isolates from the water and sediment samples collected from the site around the production platform and the control site were subjected to taxonomic identification. Approximately 100 isolates from each of the three seasonal sampling cruises were included in the data set. Two types of analyses were conducted: (1) to determine the types of exoenzymes produced by the strain (termed loosely in this report the physiological profile of the organisms) and (2) to identify the strains to the genus level. The ability of the isolates to produce three extracellular enzymes as well as the ability of the strain to survive on media lacking seawater is shown in Table 18. A summary of the taxonomy of 293 isolates examined is shown in Table 19. Microorganisms were also coded as to site and source of isolation.

Estimation of the bacterial degradation of Buccaneer field hydrocarbons proved to be a complex problem. A variety of mixed cultures, Buccaneer field isolates, and control microorganisms were tested for their ability to utilize hydrocarbons which might be found in the study area. The microorganisms were tested in conditions (high PO_4 and NO_3) assumed to be optimal for petroleum degradation. Only the "alkane" fractions were reported, although other fractions were saved for subsequent analysis. An example of a hydrocarbon found in the alkane fraction at the start of the biodegradation experiments is shown in Figure 3. Extracts of the degraded hydrocarbons were quantitated by the addition of a known quantity of deuteriated hydrocarbon and are shown in both Figure 3 and Figure 4. An example of a very successful degradation experiment is shown in Figure 4. A weathered, uninoculated control incubated for the same period of time as the biodegraded sample was used as a base line to estimate the actual amount of bacterial activity. Figure 4 shows a sample of sterile hydrocarbon inorganic salt solution which has lost some of its components after a seven-day incubation period as well as a similar solution inoculated with a bacterial culture for seven days. By this technique, the amount of abiotic hydrocarbon loss can be subtracted from the bacterial hydrocarbon degradation. The experiment shown in Figure 4 demonstrates that at least one strain (SB-1) found in the oil field is capable of utilizing most of the "alkane" components of Buccaneer condensate rather rapidly. While the abiotic loss of hydrocarbons in this experiment was significant (32%), bacterium SB-1 was able to degrade approximately 50% of the total alkanes in seven days.

A total of ten separate biodegradation experiments were completed using ten mixed cultures, three oil field isolates, and two control strains. Multiple replicates of most inoculations were measured. Both brine discharge and Buccaneer field condensate were tested as hydrocarbon sources. In several of the biodegradation experiments no measurable hydrocarbon loss occurred, at least in comparison to the weathered control. Generalization of the data was difficult, but it appears that at least in studies involving the SB-1 strain (Figure 4), three distinct groups of alkanes were observed. The first group of alkanes, C_{12} - C_{20}, are the most rapidly susceptible to bacterial degradation. The second group, C_{21} - C_{30}, are utilized at much slower rates. The group C_{31} - C_{36} is utilized very slowly in comparison to the other groups.

In contrast to the above observations, abiotic influences (weathering) exhibited the following patterns: C_{12} and C_{13} are lost very rapidly; C_{14} - C_{30} alkanes are lost at slower rates; and the C_{31} - C_{36} components are essentially stable and are lost at extremely slow rates.

Discussion

No obvious distribution pattern in total bacterial numbers was found in the data. A great deal of variation exists in the number of various types of bacteria found during different cruises or at different sites. Only a few unique patterns were noted in the microbial distribution within the study area.

As expected, there were consistently more microorganisms in the sediment than in the water samples. The water samples collected near the sediment had higher bacterial numbers than the surface water samples. The highest bacterial counts were found in the sediment during the August sampling cruise, whereas the highest numbers for the water samples were found during February. The biomass estimates did show a difference between the platform sites and the control area with higher bacterial biomass found in the control area. In eight of eleven examples, the microbial biomass was at least slightly higher in the control area than at the platform sites. Since the bacterial numbers were not lower in the platform area vs. the control site, the average microbial cell volume within the platform area must be lower. No explanation is offered for this observation at this time.

Sulfur and petroleum utilizing bacteria exhibited a discontinuity in their distribution. Oil degrading bacteria and sulfur-oxidizing bacteria appear to be more common in the oil field compared to the control site. Sulfur which has been observed in the brine discharge (B. Middleditch, personal communication) precipitates in seawater and theoretically should be found in the sediments under the production platforms. The data in this report showed a higher percentage of sulfur-oxidizing bacteria in the bottom water samples in the field (Table 13) and a large number of sulfur-metabolizing (both aerobically and anaerobically) bacteria immediately under platform A (Table 18). Sulfur-oxidizing bacteria were found in higher numbers in the sediment at all stations, but the percentages of sulfur-oxidizing bacteria in comparison to the total bacterial counts were higher in the majority of the water samples, as compared to sediment samples. A somewhat similar pattern was noted for the oil-degrading bacteria. More oil-degrading bacteria were found in the sediment than in the water column, but in general, there was a higher percentage of oil-degrading bacteria in the water column and in the oil field. Oil-degrading bacteria were found predominately in two portions of the water column: either the surface or the bottom. This might be expected because the petroleum hydrocarbons are essentially insoluble in seawater and would be expected to float on the water surface. Some oil apparently is able to coat particulate material, and when this material sinks, the hydrocarbons would be transported to the sediment surface. Oil-degrading microorganisms also appear to be more common in the warmer sampling period (July and August) than in the colder sampling period (November and February).

The intensive sampling period provides very interesting data. A large number of oil-degrading and sulfur-oxidizing bacteria were found during the intensive sampling period. Because there appears to be no pattern to the distribution of the bacteria around the platform, a careful reevaluation was made of the sampling technique used on the intensive sampling cruise. During this cruise the initial plating of the samples was conducted on the platform, and enumeration of the various physiological types was performed afterward in the laboratory. A reevaluation suggests that the techniques used probably gave unrealistically high counts. Both the sulfur-oxidizing and the oil-degrading bacterial enumeration techniques rely on the fact that either sulfur or oil was the principle "nutrient" in the media. The technique which was used on the intensive sampling cruise relies on colonies picked from the plates used to enumerate the total viable counts, and it appears in hindsight that some nutrients were probably carried over from the TVC plates to the test media. A small amount of nutrient carryover could result either in the stimulation of weakly positive strains or the creation of some false positive strains. Rechecking the results of the enumeration of the oil-degrading bacteria as per the Materials and Methods resulted in the detection of some false positive strains (i.e. the strain did not grow upon subsequent transfer to oil agar). The enumeration of hydrogen sulfide-producing bacteria was not affected by the above-mentioned problems, since the detection of hydrogen sulfide production was not affected by nutrient carryover. Although there was no pattern in the distribution of hydrogen sulfide-producing bacteria, it is significant that there was a large number of sulfur-reducing (i.e. hydrogen sulfide producers) bacteria in the sediment of the study area. Any sulfur released in the brine discharge which was not utilized by aerobic bacteria in the water column or on the surface of the sediment would be readily attacked by the large number of facultative anaerobic bacteria in the sediment.

Buccaneer oil field petroleum does not appear to affect the test organism's ability to attach to a surface. It may be that the hydrocarbons from the study area coat surfaces and may even improve primary bacterial fouling or attachment. If a larger number of isolates or a mixed culture was examined, it may be that Buccaneer hydrocarbons inhibit attachment, but we have no evidence to that effect.

The effect of Buccaneer hydrocarbons on bacterial chemotaxis appears to be very complex and may be an interesting aspect to study as either an indicator of oil pollution or a model of bacterial adaptation to oil spills. Hydrocarbons have been reported to demonstrate a negative effect on bacterial chemotaxis (Mitchel, *et al*., 1972). Our work shows at least four responses to petroleum: (1) bacterial attraction to Buccaneer discharge; (2) bacterial repulsion by Buccaneer discharge; (3) no effect of Buccaneer discharge on normal chemotactic response; (4) inhibition of normal chemotactic response by petroleum. All four possibilities were demonstrated by one or more test strains.

Buccaneer petroleum products do not appear to be particularly toxic to bacteria, especially those isolated from the oil field. Indeed, most of the strains tested were not only uninhibited, but actually grew well in the presence of the Buccaneer petroleum products. Even the control microorganisms *E. coli* and *P. aeruginosa* did not appear to be drastically affected by the Buccaneer field hydrocarbons. While it is true that these petroleum components were tested in dilute solutions (100 - 1000-fold dilutions), this simulates anything but an extreme oil spill, since a smaller spill would be quickly diluted by the water mass. The components of Buccaneer hydrocarbons appear to stimulate the growth of certain bacteria, but it is uncertain whether the bacteria are living off the hydrocarbon portion or other potential nutrients in the solution. Bactron did not appear to have any bacteriocidal effect in the samples studied. However, it must be noted that the samples studied were often stored samples where the Bactron may have been lost. Furthermore, there appears to be some doubt as to the temporal and quantitative consistency of Bactron addition to the brine discharge.

No differences were apparent between the physiological profiles or the taxonomic makeup of the oil field isolates compared to the control site strains. The normal taxonomic groups (Pseudomonas, Vibrio, Moraxella, Acinetobacter, and Aeromonas) found in oil polluted and pristine marine environments (e.g. Austin et al., 1977) were found in both study areas. The apparent lack of differentiation of taxonomic composition and physiological capacity in the oil field vs. the control site is contrary to some literature reports. Hood and coworkers (Hood et al., 1975) report that there is an increase in the diversity in an oil-rich salt marsh and that the oil in their study may represent a nutrient enrichment rather than a stress to the microbial community. On the other hand, Cobet and Guard (1973) have reported no alteration in the genera of bacteria associated with an oil spill in the marine environment. Furthermore, Walker and his coworkers (Walker et al., 1975b) have reported a decrease in the percentage of organisms capable of "lytic" (proteolytic, chitinolytic and lipolytic) activity in the presence of oil. Our data show no substantial change in gross bacterial composition between the oil field and the control site. The lack of such patterns could be the result of (1) insufficient sampling; (2) an insufficiently detailed examination of the strains studied; (3) a poor choice of control station; or (4) the oil platforms may not cause a significant effect on the gross bacterial population of the area. In next year's study, several modifications will be made to rule out some of the above-mentioned problems. In the future, only sediment samples from a single platform and the control site will be used to obtain the isolates used for taxonomic analysis. This will permit the identification of a greater number of isolates from each site. Furthermore, since the sediments are less mobile than the water mass, any existing distribution pattern should be more stable and, thus, more easily detected.

In situ bacterial degradation of hydrocarbons was difficult to measure for several reasons: (1) various mixtures or pure cultures of isolates degrade oil differently; (2) only optimal conditions, rather than natural conditions, were utilized; (3) abiotic loss of hydrocarbons often exceeded biodegradation of certain components; (4) only certain portions of the hydrocarbons lend themselves readily to analysis; (5) the general analytical technique was difficult. Although most of the mixed cultures utilized did not appear to noticeably degrade alkane hydrocarbons, certain isolates from the oil field readily attack hydrocarbons. The apparent failure of the mixed cultures to degrade oil may be a result of fallacies in the mixed culture technique (e.g. rapid selection of only a few strains in the mixed culture inoculum) or other faults in the technique used. Another important factor in interpreting the data is the emphasis given by this and other studies on the "alkane" portion of the petroleum. While short chain alkanes make up a significant portion of the Buccaneer field hydrocarbons (e.g. Figure 3), many are easily volatilized and are quickly lost from the uninoculated control. The important hydrocarbons in a natural environment may be the "non-alkane" components which were not examined in this study. It must be noted, however, that certain bacterial isolates, particularly strain SB-1 (Figure 4), do appear to quickly attack alkane hydrocarbons. While the conditions used to test SB-1 hydrocarbon degradation were artificial (high PO_4 and NO_3), the data suggest that there are strains which are at least potentially able to degrade oil spills relatively quickly, especially at the concentrations found in the oil field (see B. Middleditch, et al., 1977).

Conclusions

1. There appears to be no differences in total bacterial numbers, physiological capacity or taxonomic groups between the oil field bacterial population and the control site.

2. Dilute Buccaneer condensate and brine discharge did not appear to have a detrimental effect on either bacterial fouling on surfaces or bacterial growth.

3. Oil-degrading bacteria and sulfur-oxidizing bacteria were found in the field in greater numbers than in the control site.

4. Buccaneer brine discharge can affect bacterial chemotaxis either positively or negatively depending on the strain tested. Some bacteria isolated during the study appear to be attracted toward diluted Buccaneer brine discharge.

5. Bacteria were isolated from the oil field, which can degrade many of the components of Buccaneer petroleum. In laboratory tests, over 80% of the alkane portion of thousand-fold diluted Buccaneer condensate was lost in pure culture experiments. While a significant portion of the hydrocarbons' loss is due to abiotic weathering, the majority of the oil components lost appears to be due to bacterial degradation.

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TABLE 1

MEDIA COMPOSITION

3 Salts Solution

NaCl	23.4 g
$MgSO_4 \cdot 7H_2O$	6.94 g
KCl	0.75 g
Distilled water	1000 ml

MSWYE Broth

Proteose Peptone	1 g
Yeast Extract	1 g
3 Salts Solution	1,000 ml

pH 7.2-7.4 with NaOH

MSWYE Agar

Added 20 g Bacto Agar to 1000 ml MSWYE broth.

Oil MPN

3 Salts Solution	1,000 ml
KNO_3	1 g

After autoclaving, add 5 ml of sterile 10% K_2HPO_4 to each liter of solution. Dispense aseptically 5 ml of the above into sterile test tubes. Overlay with 0.1 ml of filter sterilized oil.

Sulfur MPN

Solution A

$NH_4H_2PO_4$	5 g
K_2HPO_4	5 g
Distilled water	1,000 ml

pH to 7.4 and autoclave.

Solution B

3 Salts Solution	987 ml
1% Bromthymol Blue	3 ml

Autoclave Solutions A and B separately and cool. Add 10 ml of Solution A to 990 ml of Solution B. Dispense aseptically 5 ml aliquots into sterile test tubes. Add a small amount of sterilized sulfur to each tube.

Table 2. Taxonomic Key for the Identification of Marine Bacteria

1.	Gram reaction	
	Positive	2
	Negative	8
2.	Rods	3
	Cocci	5
3.	Forms spores	*Bacillus*
	Non-sporing	4
4.	Catalase positive	Coryneforms
	Catalase negative	*Lactobacillus*
5.	Catalase positive	6
	Catalase negative	*Streptococcus*
6.	MOF fermentative	*Staphylococcus*
	MOF other than fermentative	7
7.	Motile	*Planococcus*
	Non-motile	*Micrococcus*
8.	MOF oxidative	9
	MOF fermentative	15
	MOF alkaline	19
	MOF no reaction	24
9.	Oxidase positive	10
	Oxidase negative	13
10.	Motile	11
	Non-motile	*Pseudomonas* (atypical Gp1 or Gp2) - *Flavobacterium* (pigmented)
11.	Peritrichous flagella	*Achromobacter* - *Chromobacter* - *Agrobacterium*
	Polar flagella	12
12.	Fluorescent pigment produced	*Pseudomonas fluorescens* Gp1
	No fluorescent pigment	*Pseudomonas*
13.	Motile	14
	Non-motile	*Acinetobacter*
14.	Peritrichous flagella	*Achromobacter*
	Polar flagella	*Pseudomonas* (atypical Gp2 or *P. maltophilia*)
15.	Peritrichous flagella	16
	Polar flagella	17
16.	Oxidase positive	*Lucibacterium*
	Oxidase negative	*Enterobacteriaceae*

Table 2. (continued)

17.	MOF gas production	*Aeromonas*
	No gas production	18
18.	0/129 sensitivity	*Vibrio* (arginine decarboxylase negative)
	0/129 resistance	*Aeromonas* (arginine decarboxylase positive)
19.	Oxidase positive	20
	Oxidase negative	22
20.	Motile	21
	Non-motile	*Moraxella* - *Cytophaga* - *Flavobacterium* - *Flexibacter*
21.	Peritrichous flagella	*Alcaligenes*
	Polar flagella	*Pseudomonas* (GP3) *Spirillum* (microaerophilic)
22.	Motile	23
	Non-motile	*Acinetobacter lwoffi* (nitrate negative)
23.	Polar flagella	*Pseudomonas* (atypical Gp3)
	Peritrichous flagella	*Alcaligenes* (atypical)
24.	Oxidase positive	25
	Oxidase negative	27
25.	Motile	26
	Non-motile	*Pseudomonas* - *Cytophaga* - *Flavobacter* - *Flexibacter* - *Moraxella*
26.	Peritrichous flagella	*Achromobacter* - *Agrobacterium*
	Polar flagella	*Pseudomonas* (Gp3) Spirillum (microaerophilic)
27.	Motile	2 28
	Non-motile	*Acinetobacter lwoffi* (nitrate negative)
28.	Peritrichous flagella	*Achromobacter*
	Polar flagella	*Pseudomonas* (Gp3)

TABLE 3

CRUISE 1 - BACTERIAL ANALYSIS - July 18-19

Source	Station	Depth (M)	TVC x 10^2	Oil Degraders (%)	S-Oxidizers (%)	Biomass* $(gC/ml) \times 10^{-9}$
Water	Platform 288 A	surface	0.83	2.90	0.24	2.95
		9	1.27	0.31	0.0	7.56
		18	1.97	0.47	0.060	12.1
	288 A + 1 mile	surface	2.50	4.40	4.40	
		9	0.90	0.26	0.166	
		18	1.90	0.23	0.084	
	288 A + 1½ mile	surface	0.73	0.32	0.041	
		9	1.67	0.14	0.043	
		18	2.93	0.32	0.819	
	288 A + 2 miles	surface	1.07	1.03	0.041	
		9	1.60	0.24	0.045	
		18	1.73	0.13	0.167	
	Control	surface	1.20	0.36	0.0	2.36
		9	1.33	0.17	0.068	2.93
		18	3.93	0.06	0.015	12.9
Sediment	Platform 288 A		1,440.0	0.016	0.008	
	288 A + 1 mile		62.5	0.16	0.0	
	288 A + 1½ mile		2,350.0	0.34	0.013	
	288 A + 2 miles		151.0	1.50	0.068	
	Control		1,320.0	0.016	0.013	
Brine Discharge			310	0.04	0.04	

*Biomass data presented is for only those stations specified in the contract, data not available for any other stations.

TABLE 4

CRUISE 2 - BACTERIAL ANALYSIS - August 26-27

Source	Station	Depth (M)	TVC x 10^2	Oil Degraders (%)	S-Oxidizers (%)	Zn Resistance	Cr Resistance
Water	Platform 288 A	surface	2.10	0.17	0.20	17.62	89.05
		9.0	3.80	0.09	0.06	19.21	57.11
		18.0	5.40	8.52	20.37	22.22	64.81
	288 A + 1 mile	surface	2.45	0.15	0.09	5.31	70.61
		9.0	5.50	0.07	0.04	6.00	21.82
		18.0	5-10	0.07	0.05	7.84	52.94
	288 A + 2 miles	surface	3.50	0.60	0.12	16.29	52.86
		9.0	2.40	1.83	0.10	19.58	62.50
		18.0	2.60	0.88	0.17	15.38	69.23
	Platform 288 B	surface	1.00	0.11	0.93	57.00	90.00
		9.0	3.05	0.05	0.14	10.82	19.67
		18.0	2.60	0.14	0.29	18.08	47.31
	288 B + 1 mile	surface	1.90	0.02	0.12	5.26	38.42
		9.0	2.10	0.02	0.19	17.62	55.71
		18.0	2.60	0.14	0.29	18.08	47.31
	288 B + 2 miles	surface	4.40	0.02	0.05	15.23	55.23
		9.0	6.25	0.01	0.74	9.12	69.92
		18.0	4.10	0.02	0.10	14.63	65.85
	Control Area	surface	4.80	0.01	0.05	7.71	51.46
		9.0	4.80	*	0.09	11.86	*
		18.0	5.70	*	0.04	8.25	55.61

Table 4. Cruise 2 - Bacterial analysis (continued)

Source	Station	Depth (M)	TVC x 10^2	Oil Degraders (%)	S-Oxidizers (%)	Zn Resistance	Cr Resistance
Sediment	Platform A	20	80,321.00	*	*	0.48	0.65
	A + 1 mile	20	393,327.00	0.001	0.00005	2.15	*
	A + 2 miles	20	1,709.00	0.07	0.218	0.12	1.60
	Platform B	20	315,217.00	0.002	0.002	0.18	0.174
	B + 1 mile	20	136,525.00	0.001	0.0031	0.18	0.374
	B + 2 miles	20	36,585.00	0.05	0.055	1.86	1.72
	Control Area	20	38,560.00	0.003	0.00006	0.53	1.00

TABLE 5

CRUISE 3 - BACTERIAL ANALYSIS - November 11-12

Source	Station	Depth (M)	TVC x 10^2	Oil Degraders (%)	S-Oxidizers (%)	Biomass * (gC/ml) x 10^{-9}
Water	Platform 288 A	surface	1.4	0.0	0.0650	0.6524
		10	5.2	0.0	0.0069	2.1684
		18	2.4	0.0	0.6250	0.8472
	288 A + 1 mile	surface	0.8	0.0	0.045	--
		10	0.4	0.0	0.00	--
		18	2.0	0.02	0.10	--
	288 A + 2 miles	surface	1.2	0.0	0.076	--
		10	0.0	0.0	--	--
		18	0.6	0.0667	1.67	--
	Platform 288 B	surface	2.4	0.0	0.0379	1.0728
		10	2.6	0.0	0.1654	0.9568
		18	1.8	0.0	0.2389	0.8154
	288 B + 1 mile	surface	1.4	0.0	0.0650	--
		10	12.0	0.0	0.00608	--
		18	0.2	0.0	0.4550	--
	288 B + 2 miles	surface	0.4	0.0	0.1825	--
		10	1.4	0.0	0.0436	--
		18	9.0	0.0	0.2556	--
	Control	surface	1.4	0.0	0.11	0.4242
		10	4.2	0.0	0.036	1.4410
		18	2.6	1.54	0.035	--

Table 5. Cruise 3 - Bacterial Analysis (continued)

Source	Station	Depth (M)	TVC x 10^2	Oil Degraders (%)	S-Oxidizers (%)	Biomass* (gC/ml) x 10^{-9}
Sediment	Platform 288 A	20	2.53	0.0008	0.0004	--
	288 A + 1 mile	20	20.4	0.00069	0.00020	--
	288 A + 2 miles	20	12.7	0.00063	0.00039	--
	Platform 288 B	20	15.5	0.00374	0.000374	--
	288 B + 1 mile	20	17.8	0.00034	0.000056	--
	288 B + 2 miles	20	26.2	0.00650	0.0011	--
	Control	20	27.6	0.00058	0.0030	--

*Biomass data presented is for only those stations specified in the contract. Data is not available for any other stations.

TABLE 6

CRUISE 4 - BACTERIAL ANALYSIS - February 23-24

Source	Station	Depth (M)	TVC x 10^2	Oil Degraders (%)	S-Oxidizers (%)	Biomass * (gC/ml) x 10^{-9}
Water	Platform 288 A	surface	33	0	0.0069	102
		10	14	0	0.0064	52.2
		18	10	0.0036	0.023	39
	288 A + 1 mile	surface	23	0	0.0186	--
		10	12	0	0.0075	--
		18	18	0	0.012	--
	288 A + 2 miles	surface	29	0.0012	0.0051	--
		10	15	0	0.0286	--
		18	4.5	0	0.0088	--
	Platform 288 B	surface	10.0	0.15	0.015	42.8
		10	1.3	0	0	4.75
		18	0.9	0	0.10	3.02
	288 B + 1 mile	surface	15.0	0	0.006	--
		10	1.7	0	0	
		18	1.3	0	0.069	--
	288 B + 2 miles	surface	10	0	0.023	--
		10	5.7	0	0.007	--
		18	1.1	0	0.39	--
	Control	surface	44	0	0.003	185
		10	38	0	0.024	200
		18	28	0	0.014	9.83
	Control	surface	19	-	-	--
		10	25	-	-	--
		18	15	-	-	--

Table 6. Cruise 4 - Bacterial Analysis (continued)

Source	Station	Depth (M)	TVC x 10^2	Oil Degraders (%)	S-Oxidizers (%)	Biomass* (gC/ml) x 10^{-9}
Sediment	Platform 288 A	20	7,050	0.00056	0.0104	--
	288 A + 1 mile	20	565	0.016	0.0106	--
	288 A + 2 miles	20	3,500	0.024	0.024	--
	Platform 288 B	20	2,300	0.011	0.0013	--
	288 B + 1 mile	20	3,400	0.0097	0.00088	--
	288 B + 2 miles	20	12,500	0.012	0.012	--
	Control	20	5,050	0.039	0.0079	--

*Biomass data presented is for only those stations specified in the contract. Data is not available for any other stations.

TABLE 7

HEAVY METAL RESISTANT BACTERIA

Source	Station	Depth (M)	Zn Resistance	Cr Resistance
Water	Platform 288 A	surface	18	89
		9	19	57
		18	22	65
	288 A + 1 mile	surface	5	71
		9	6	22
		18	8	53
	288 A + 2 miles	surface	16	53
		9	20	63
		18	15	69
	Platform 288 B	surface	57	90
		9	11	20
		18	11	100
	288 B + 1 mile	surface	5	38
		9	18	56
		18	18	47
	288 B + 2 miles	surface	15	55
		9	9	70
		18	15	66
	Control	surface	8	52
		9	12	-
		18	8	56
Sediment	Platform 288 A	20	.5	.65
	288 A + 1 mile	20	2.2	-
	288 A + 2 miles	20	.1	1.6
	Platform 288 B	20	.2	.2
	288 B + 1 mile	20	.2	.4
	288 B + 2 miles	20	1.9	1.7
	Control	20	.5	1.0

TABLE 8

TOTAL VIABLE COUNTS PER ML WATER

Station	Depth	July * Cruise I	August Cruise II	November Cruise III	February Cruise IV	Average
Platform 288 A	Top	83	210	240	3,300	958
	Middle	127	380	260	1,400	542
	Bottom	2,733	540	180	1,000	1,113
	Average	981	377	227	1,900	871
288 A + 1 mile	Top	250	245	140	2,300	734
	Middle	90	550	1,200	1,200	760
	Bottom	190	510	20	1,800	630
	Average	177	435	453	1,767	908
288 A + 2 miles	Top	1,067	350	40	2,900	1,089
	Middle	160	240	140	1,500	510
	Bottom	173	260	900	450	446
	Average	467	283	360	1,617	682
Platform 288 B	Top	--	100	240	1,000	447
	Middle	--	305	260	130	232
	Bottom	--	140	180	90	137
	Average	--	182	227	380	263
288 B + 1 mile	Top	--	190	80	1,500	590
	Middle	--	210	40	170	140
	Bottom	--	260	200	130	197
	Average	--	220	107	600	309
288 B + 2 miles	Top	--	440	120	1,000	520
	Middle	--	625	0	570	398
	Bottom	--	410	60	110	193
	Average	--	492	60	560	371
Control	Top	120	480	140	3,150	973
	Middle	133	480	420	3,150	1,046
	Bottom	393	570	260	890	528
	Average	215	510	273	2,397	849

* July cruise not included in contract work. Only 4 stations were sampled.

TABLE 9

TOTAL VIABLE COUNTS - SEDIMENT (x 10^{-2})

Station	July Cruise I	August Cruise II	November Cruise III	February Cruise IV
Platform 288 A	1,440	80,321	253	7,050
288 A + 1 mile	62	393,237	2,040	565
288 A + 2 miles	151	1,709	1,270	3,500
Platform 288 B	--*	315,217	1,550	2,300
288 B + 1 mile	--	136,525	1,780	3,400
288 B + 2 miles	--	36,585	2,620	12,500
Control	1,320	38,560	2,760	5,050

*July cruise not included in contract. Only 4 stations were sampled.

TABLE 10

TOTAL VIABLE COUNTS AT DIFFERENT DEPTHS IN THE WATER COLUMN*

Station	Top	Middle	Bottom	Average for Station
		Depths		
Platform 288 A	178	256	1,151	528
288 A + 1 mile	212	613	240	355
288 + 2 miles	486	180	444	370
Platform 288 B	170	283	160	204
288 + 1 mile	135	125	230	163
288 B + 2 miles	280	313	235	276
Control	247	344	408	333
Average for depth	244	302	410	

* Average of 4 cruises

TABLE 11

TOTAL VIABLE COUNTS OF WATER SAMPLES AVERAGED PER CRUISE

Station	July * Cruise I	August Cruise II	November Cruise III	February Cruise IV	Average
Platform 288 A	981	377	227	1,900	871
288 A + 1 mile	177	435	453	1,767	708
288 A + 2 miles	467	283	360	1,617	682
Platform 288 B	--	182	227	380	263
288 B + 1 mile	--	220	107	600	309
288 B + 2 miles	--	492	60	560	371
Control	215	510	273	2,397	849
Average	169	357	243	1,317	--

* July cruise not included in contract. Only 4 stations were sampled.

TABLE 12

WATER COLUMN BACTERIAL BIOMASS (x 10^9)

Cruise	Water Depth	Platform 288 A	Control Site
I	surface	3.0	2.3
	middle	7.6	2.9
	bottom	2.1	2.9
II	middle	18.9	22.1
	bottom	7.6	26.6
III	surface	10.7	6.5
	middle	9.6	22.7
	bottom	8.2	8.5
	surface	4.2	
	middle	14.4	
IV	surface	42.8	185.0
	middle	4.8	200.0
	bottom	3.0	9.8
	surface	102.0	
	middle	52.2	
	bottom	39.0	

TABLE 13

PERCENT SULFUR OXIDIZERS IN WATER COLUMN

Station	Depth	July* Cruise I	August Cruise II	November Cruise III	February Cruise IV
Platform 288 A	Top	0.2	0.2	0.307	0.0069
	Middle	0.0	0.06	0.017	0.0064
	Bottom	0.06	20.4	0.625	0.023
288 A + 1 mile	Top	4.4	0.09	0.288	0.0186
	Middle	0.2	0.04	0.0	0.0075
	Bottom	0.08	0.05	0.375	0.012
288 A + 2 miles	Top	0.04	0.1	0.075	0.0051
	Middle	0.05	0.1	0.0	0.0286
	Bottom	0.2	0.2	0.383	0.0088
Platform 288 B	Top	--	0.9	0.038	0.015
	Middle	--	0.1	0.058	0
	Bottom	--	0.7	0.239	0.10
288 B + 1 mile	Top	--	0.1	0.064	0.006
	Middle	--	0.2	0.0058	0
	Bottom	--	0.3	0.450	0.069
288 B + 2 miles	Top	--	0.05	0.175	0.023
	Middle	--	0.8	0.022	0.007
	Bottom	--	0.1	0.026	0.39
Control	Top	0.0	0.05	0.107	0.003
	Middle	0.7	0.09	0.102	0.024
	Bottom	0.2	0.04	0.035	0.014

* July cruise not included in contract. Only 4 stations were sampled.

TABLE 14

PERCENT OIL DEGRADERS IN WATER COLUMN

Station	Depth	July Cruise I *	August Cruise II	November Cruise III	February Cruise IV
Platform 288 A	Top	2.9	0.2	0.0064	0.0
	Middle	0.3	0.1	0.0	0.0
	Bottom	0.5	8.52	0.0	0.0036
288 A + 1 mile	Top	4.4	0.15	0.0	0
	Middle	0.3	0.07	0.0	0
	Bottom	0.2	0.07	0.02	0
288 A + 2 miles	Top	1.0	0.6	0.0	0.0012
	Middle	0.2	1.8	0.0	0
	Bottom	0.1	0.9	0.067	0
Platform 288 B	Top	--	0.1	0.0	0.15
	Middle	--	0.05	0.0	0
	Bottom	--	0.04	0.022	0
288 B + 1 mile	Top	--	0.02	0.0	0
	Middle	--	0.02	0.0	0
	Bottom	--	0.1	0.0	0
288 B + 2 miles	Top	--	0.02	0.0	0
	Middle	--	0.01	0.0	0
	Bottom	--	0.02	0.0	0
Control	Top	0.4	0.01	0.0	0
	Middle	0.2	--	0.0	0
	Bottom	0.06	--	0.015	0

* July cruise not included in contract. Only 4 stations were sampled.

TABLE 15

INTENSIVE SAMPLING - BUCCANEER SEDIMENT

Station*	Ft. from Platform	TVC/g Sed. (x 10^6)	Oil Degraders %	Sulfur Oxidizers %	H_2S %
AO	0	3.55	91.0	12.0	38.0
AW1	25	2.47	97.0	16.0	36.0
AW2	50	8.27	92.0	52.0	14.0
AW3	75	2.54	--	--	--
AW4	100	1.25	59.0	43.0	55.0
AE1	25	1.38	--	--	--
AE2	50	3.68	78.0	78.0	12.0
AE3	75	2.14	48.0	65.0	0.0
AE4	100	2.34	54.0	71.0	41.0
SO	0	5.58	97.0	15.0	51.0
SW1	25	5.34	72.0	--	1.0
SW2	50	TNTC**	93.0	59.0	81.0
SW3	75	0.235	--	--	--
SW4	100	2.27	55.0	65.0	9.0
SE1	25	0.435	--	--	--
SE2	50	1.25	83.0	38.0	42.0
SE3	75	1.63	--	--	--
SE4	100	1.95	70.0	56.0	40.0

* AW = Platform 288 A tract line west
AE = Platform 288 A tract line east
SW = Satellite platform 288 - 3 tract line west
SE = Satellite platform 288 - 3 tract line east

** TNTC = too numerous to count

TABLE 16

EFFECT OF DILUTE BUCCANEER BRINE DISCHARGE ON BACTERIAL CHEMOTAXIS

		Number of Organisms Attracted	
Attractant	Test Microorganism	With Brine Discharge	Without Brine Discharge[a]
Arginine	*E. coli*	12	78
	D-4[b]	TNTC[c]	390
Glucose	*E. coli*	36	72
	D-4	100	700
Salt Solution	*E. coli*	59	200
	D-4	10	TNTC

[a] 1% brine discharge added to 3 salts solution

[b] D-4 is an isolate (#191) collected from near Platform A.

[c] TNTC = too numerous to count

TABLE 17

SUMMARY OF SELECTED CHEMOTAXIS EXPERIMENTS

Test Organisms	Attractants					
	Arginine		Glucose		Brine Discharge	
	3SS	3SS + Brine[a]	3SS	3SS + Brine	3SS	3SS + Brine[b]
E. coli	+[c]		+		-	
Pseudomonas aeruginosa	0	+	0	+	0	+
I-15[d]	+		+		+	
I-68	+		+		-	
I-11	-	+	-	+	-	+
I-80	+	+	+	+	+	+

[a] Experiments were conducted using either 3 Salts Solution or 3 Salts Solution + diluted brine discharge.

[b] Diluted brine discharge was used as an attractant.

[c] + = chemotaxis toward attractant.
- = chemotactic response away from potential attractant.
0 = no response.

[d] I-15, I-68, I-11, and I-80 are isolates from the study area.

TABLE 18

PHYSIOLOGICAL PROFILE OF ISOLATES

Cruise	Station	Percentage Proteolytic	 Chitinoclastic	 Lipolytic	 Salt Requiring
I	Platform 288 A	76	19	38	68
	288 A + 2 miles	69	31	54	23
	Control	54	24	56	61
II	Platform 288 A	67	27	60	27
	Platform 288 B	62	31	54	23
	Control	65	24	53	59
III	Platform 288 A	42	29	4	42
	Platform 288 B	73	36	23	68
	Control	58	13	13	50
IV	Platform 288 A	52	24	24	55
	Platform 288 B	27	15	8	38
	Control	23	23	21	35

TABLE 19

TAXONOMIC GROUPS FOUND IN STUDY AREA

		Genera														
Cruise	Station	Pseudomonas GP3	Acinetobacter	Coryneforms	Alcaligenes	Aeromonas	Vibrio	Moraxella	Cytophaga	Flavobacter	Pseudomonas	Lucibacterium	Pseudomonas GP2	Acinetobacter lwoffi	Lactobacillus	Thiobacillus
I	Plateform 288 A	18[a]	-	3	-	42	12	3	3	9	6	-	3	-	-	-
	288 A + 2 miles	31	15	23	8	15	-	-	-	-	8	-	-	-	-	-
	Control	32	11	2	-	19	19	4	-	4	6	2	-	-	-	-
III	Platform 288 A	9	30	-	-	13	9	22	-	4	9	4	-	-	-	-
	Platform 288 B	39	17	-	-	17	11	11	-	-	-	-	-	6	-	-
	Control	9	35	-	-	17	17	13	-	-	-	-	-	9	-	-
IV	Platform 288 A	26	-	-	-	14	12	14	-	-	24	-	-	7	-	-
	Platform 288 B	24	3	-	-	12	3	12	-	-	29	-	-	15	-	-
	Control	25	-	-	-	9	14	14	-	-	23	2	-	9	2	2

[a] Percentage of population belonging to genera

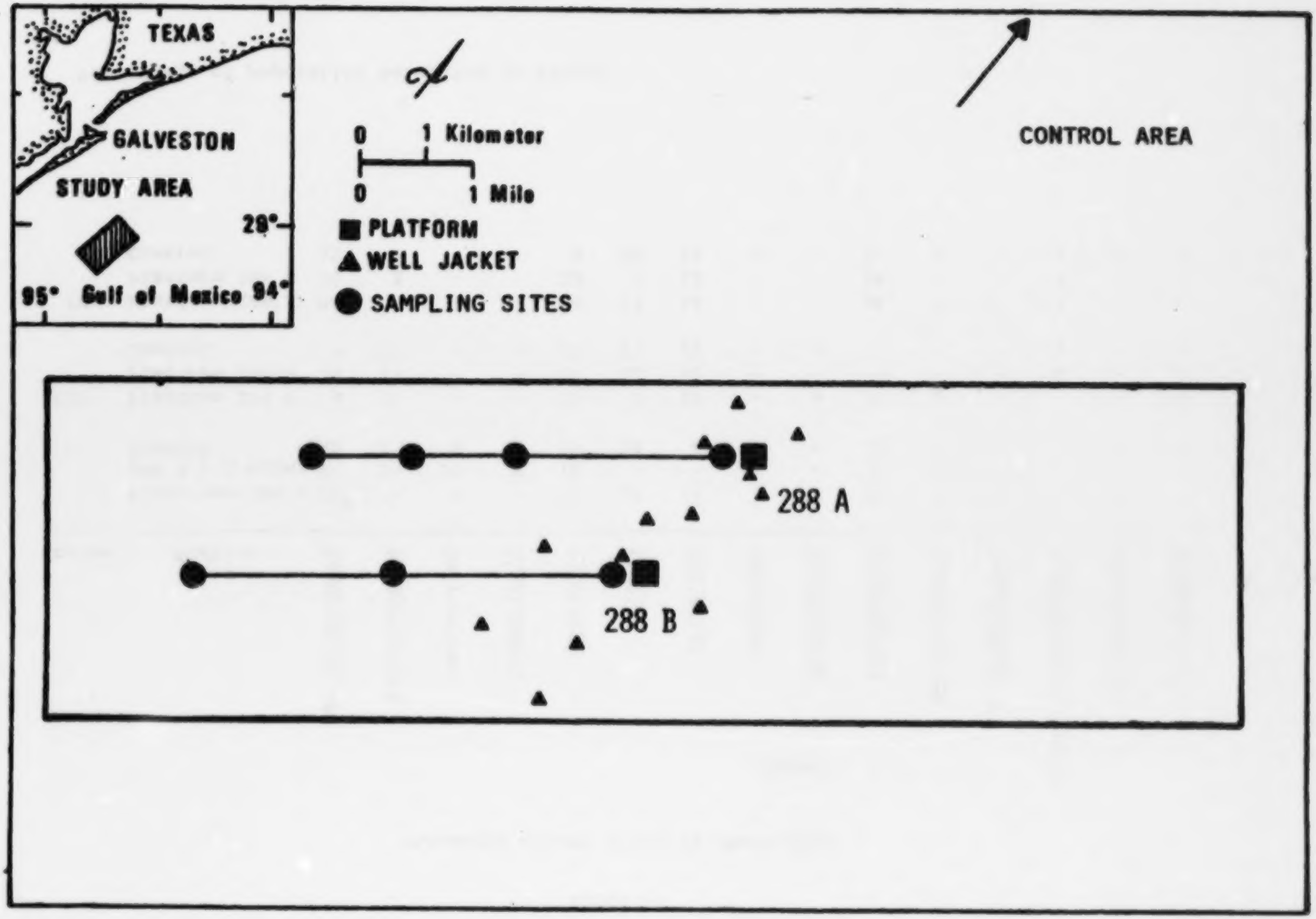

TEXAS
GALVESTON
STUDY AREA
29°
95°
Gulf of Mexico
94°
0
1 Kilometer
0
1 Mile
■ PLATFORM
▲ WELL JACKET
● SAMPLING SITES
CONTROL AREA
288 A
288 B

FIGURE 1. LOCATION OF SAMPLING SITES - BACTERIAL ANALYSIS

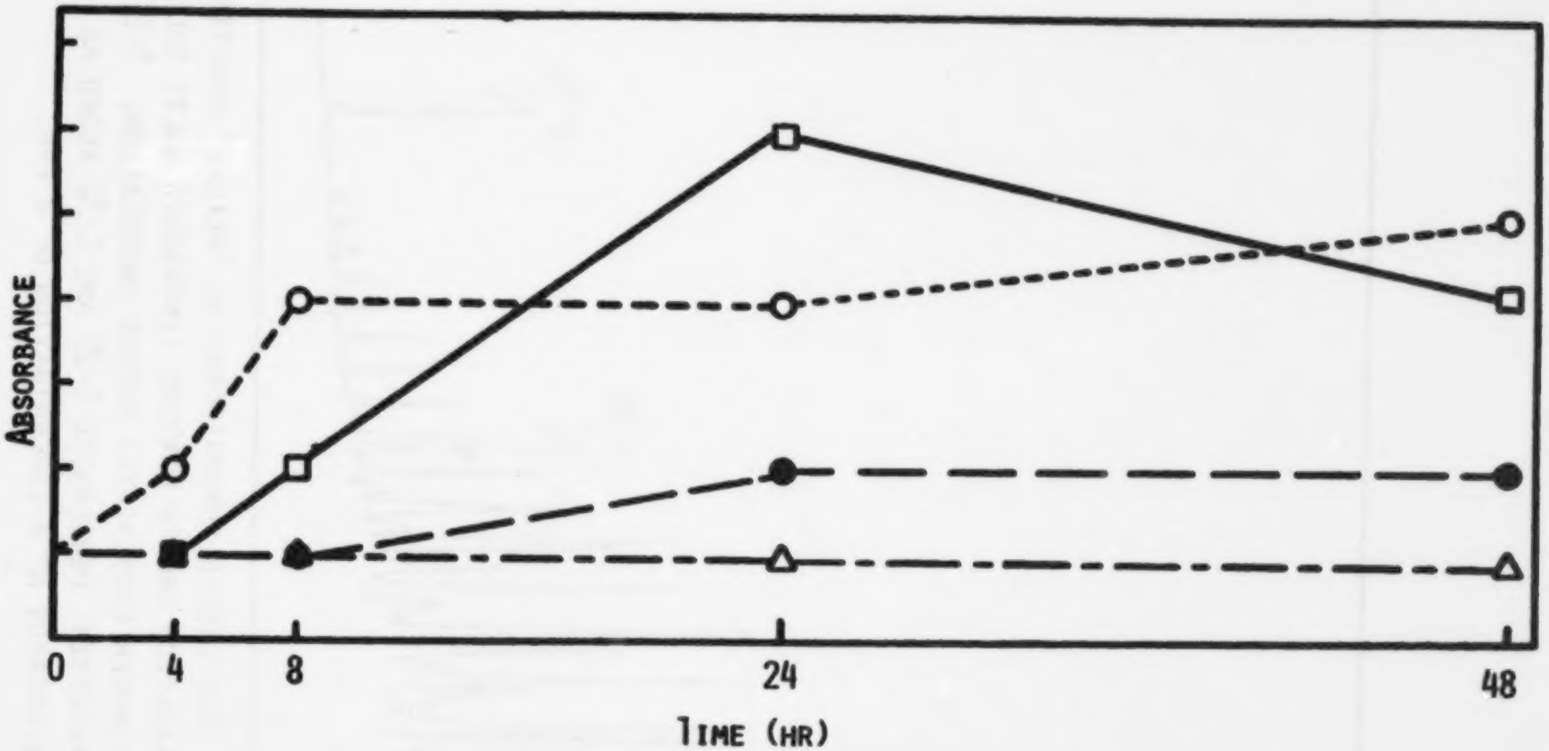


Figure 2. Growth of bacterial cultures in Puccaneer brine discharge +/- bactron.
○ = mixed culture from Platform A in 10^{-2} discharge with bactron
□ = mixed culture from Platform A in 10^{-2} discharge without bactron
● = mixed culture from Platform A in salt solution without discharge
△ = E. coli in 10^{-2} discharge with bactron

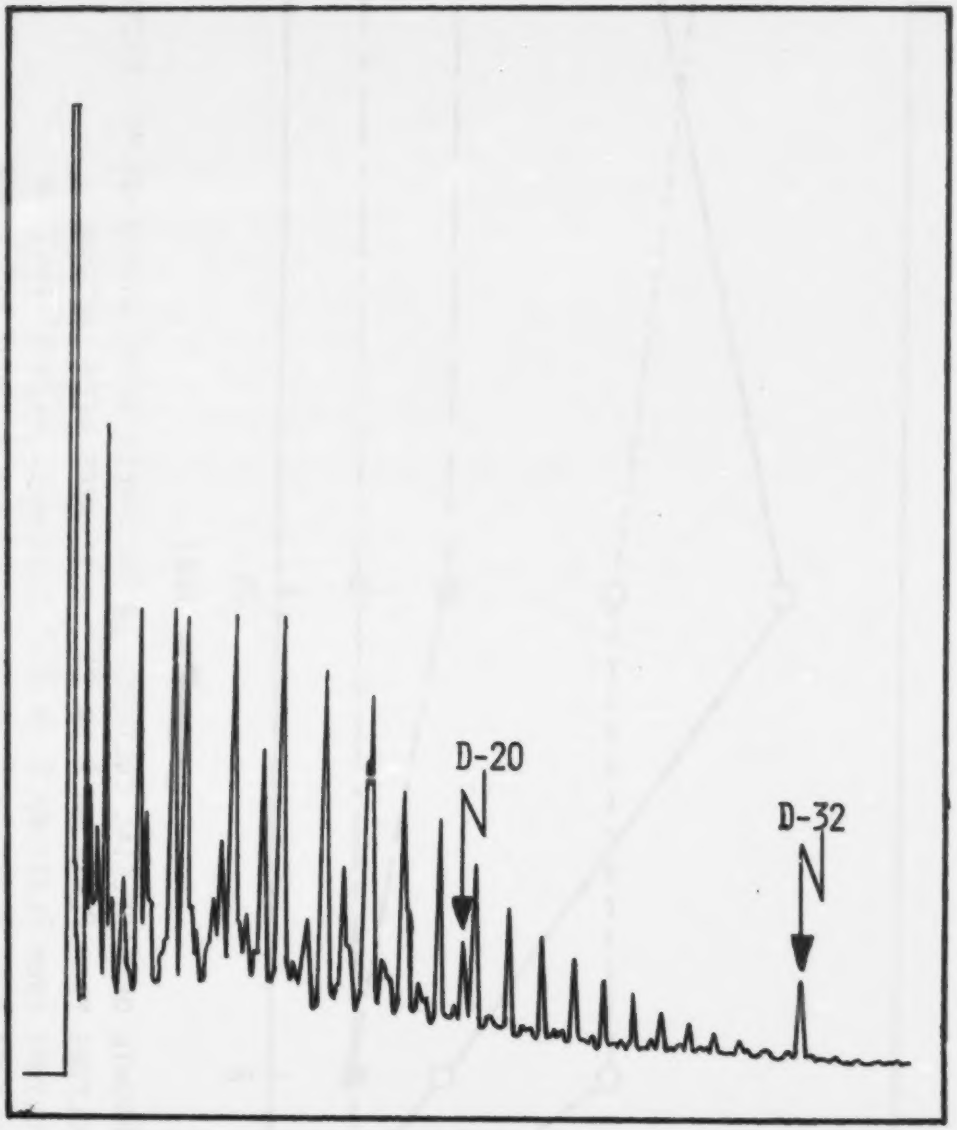
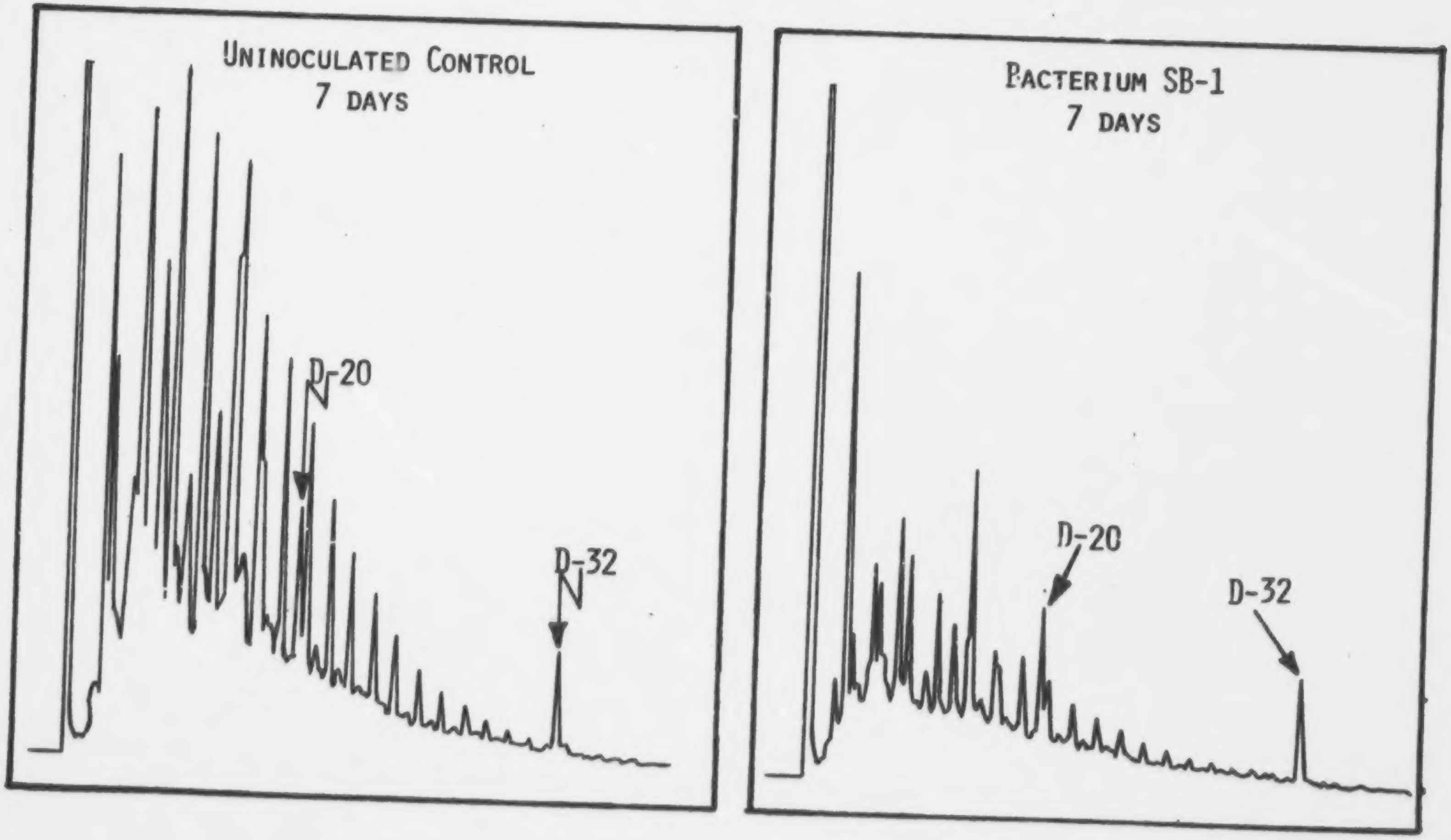


Figure 3. Gas-liquid chromatogram of "alkane" fraction of biodegradation growth mixture (inorganic salts solution + 0.1% Buccaneer condensate) before inoculation. D-20 and D-32 represent deuterated C-20 and C-32 added as internal standards at a concentration of 2 ppm.

Figure 4. Gas-liquid chromatogram of uninoculated weathered control vs. biodegraded sample. D-20 and D-32 are deuterated internal standards added at a concentration of 2 ppm.



A STUDY OF THE EFFECTS OF BUCCANEER OIL FIELD STRUCTURES AND ASSOCIATED EFFLUENTS ON BIOFOULING COMMUNITIES AND THE ATLANTIC SPADEFISH (*Chaetodipterus faber*)

Annual Report
for Work Unit 2.3.8

by

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ABSTRACT

Studies of the biofouling communities were performed in the Buccaneer Oil Field during 1977-1978 to determine the effects of structures and produced water discharge on biofouling communities. The structures were found to serve as focal points for a rich and diverse biofouling community and a complex assemblage of platform associated macrobiota. The platforms harbor sessile and motile invertebrates and fish that would not be present were it not for the existence of the artificial substrate. In addition, fish which would normally be scattered throughout a very large area are concentrated at platforms. The platforms are equivalent in many respects to reefs and are important to the Gulf ecosystem in far greater measure than can be accounted for by their relative area.

The produced water had detrimental effects on the fouling communities in at least the immediate vicinity of the discharge. Evidence of adverse effects included low biomass and density of most fouling organisms, low survival rates of barnacles and low rates of produciton and recolonization. Community structure was greatly altered in the area of produced water discharge.

Results of marking studies in the Buccaneer Oil Field indicated that the Atlantic spadefish was habitat faithful, i.e., they did not characteristically move from structure to structure but spent most of their time at a given platform. In contrast to results of previous studies in the field indicating spadefish to be a grazer on the fouling community, the fish was found to be primarily dependent upon plankton and suspended particulate materials for food. During winter, spadefish populations in the Buccaneer Oil Field suffered a disease epidemic.

That the produced water had any measurable impact was surprising and disturbing because of the characteristic low level of contaminants in the stream and the rapid dilution of the effluent. In future studies, emphasis should be placed upon research describing chronic effects of low-level discharges and determination of toxic factors.

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INTRODUCTION

In March of 1938, the first oil well drilled in the open waters of the Gulf of Mexico was completed about 12.4 km offshore Louisiana. However, significant offshore leasing and development of oil and gas deposits in the Gulf was not greatly accelerated until passage of the Submerged Lands Act and Outer Continental Shelf Lands Act of 1953 defined ownership and jurisdiction of the natural resources of the seabed of the Gulf continental shelf. Following these acts, development activities accelerated rapidly. Oil and gas are currently being produced in the Gulf from 2,079 platforms in waters up to 113 m deep (Danenberger 1976).

In effect, offshore oil field structures provide hard substrate allowing for the development of artificial reefs. The structures are rapidly colonized by a multitude of sessile invertebrates and other marine organisms, including fish. Studies describing the biology of oil field structures in the Gulf of Mexico surfaced in 1955 with a description of the zonation and composition of organisms growing on a production platform offshore Texas and colonization of steel pipes placed at different depths (Gunter and Geyer 1955). Pequegnat and Pequegnat (1968) described some ecological aspects of marine fouling in the northeastern Gulf and additional studies describing the fouling communities on production platforms in the northwestern Gulf were reported by George and Thomas (undated) and Fotheringham (1977). The latter study was performed in the Buccaneer Oil Field.

Shinn (1974) and Sonnier *et al.* (1976) have described fish populations around oil platforms in the northwestern Gulf of Mexico, and Hastings *et al.* (1976) described fish populations around U.S. Navy Research Platforms in the northeastern Gulf. Shinn (1974) also described the vertical zonation of fishes around the platforms. He listed spadefish (*Chaetodipterus faber*), barracuda (*Sphyraena barracuda*), lookdown (*Selene vomer*), and sheepshead (*Archosargus probatocephalus*) to be characteristic of the upper water layers; red snapper (*Lutjanus campechanus*) and large groupers (*Epinephelus nigritus, Epinephelus itajara*) were described to be largely bottom fish that spent some of their time in the midwater layers; and restricted to the bottom were speckled trout (*Cynoscion nebulosus*), sand trout (*Cynoscion* sp.) and flounders (*Paralichthys* sp.)

Hastings *et al.* (1976) found that in the northeastern Gulf, platform pilings and cross-members with their encrusting organisms and associated motile fauna provided food and shelter for numerous fish species. Organisms that were observed grazing on the fouling community included spadefish, filefish, chubs, sparids and some grunts. Most of the rig grazers were diurnal and became inactive at night. Several diurnally schooling species were found to be abundant beneath the platforms during the day, where they were afforded some protection from predation. These fishes dispersed into surrounding open areas at night to feed. Examples of fishes with this feeding behavior were clupeids, carangids, lutjanids, and grunts. Large numbers of piscivorous fish appeared attracted to the platform habitat to feed on the numerous small fishes associated with the structure. Many species migrated away from the platform during the colder months, and repopulation by these forms occurred during spring and summer.

To summarize, one effect of oil platforms in the Gulf of Mexico is known. They serve as focal points for a rich and diverse biofouling community and a complex assemblage of platform-associated macrobiota. The platform harbors sessile and motile invertebrates and fish which would not be present were it not for the existence of artificial substrate. In addition, fish which would normally be found scattered throughout a very large area (such as pelagic predators and baitfish) are concentrated in the immediate vicinity of platforms, attracted to the food and/or shelter they provide. Platforms are, therefore, equivalent in many respects to reefs and are important to the Gulf ecosystem in far greater measure than can be accounted for by their relative area.

Studies of platform associated communities have been descriptive in nature; i.e., they have dealt with the general composition and vertical zonation of associated organisms. The purpose of our studies was to delimit the effects of discharges on the biota.

The specific goals of our studies, performed during 1977-1978, were to identify the impacts of discharges from the platforms on species diversity and biomass of the biofouling community and on selected ecosystem processes, using condition and production as indicators. Complementary studies of spadefish and barnacles were designed to evaluate trophic dependencies and feeding rates of these dominant organisms. The program was divided into routine and experimental sampling. Routine sampling consisted of activities that we believed with certainty would provide usable results (scraping and recolonization studies of the biofouling community), whereas the experimental sampling consisted of research efforts where the risk of failure was high due to the novelty of the approach.

The objectives of the routine sampling program were

1. to compare biomass and diversity of the fouling community on different structures in terms of depth and proximity of discharges based upon scraping samples.

2. to compare seasonal recolonization rates of the biofouling community at near surface depths under the discharge pipe to an area on a satellite well without a discharge. This was to have been an artificial substrate study, but hurricanes and storms necessitated using the platform as the subject substrate.

3. using the above data, to estimate differences in net production rates of the biofouling community in discharge-affected and non-affected areas.

The objectives of the experimental program were

1. to define population levels and in-field movements of the Atlantic spadefish, the dominant fish reported to be a grazer on the fouling community.
2. to determine food, feeding rates, feeding periodicity, and condition of Atlantic spadefish.
3. to determine feeding rates and periodicity of the dominant fouling organism, the barnacle, *Balanus tintinnabulum*.
4. to evaluate the effects of the produced water discharge on uptake rates of dissolved oxygen using respirometry techniques.

By contract modification we collected additional samples (water, surficial sediments, bottom cores, and suspended sediments) for analysis by other investigators and provided a description of an observed spadefish disease epidemic of the winter-spring period of 1978.

METHODS AND MATERIALS

Standing Stock Biomass and Diversity of the Biofouling Community

Field Methods

Divers used underwater scraping techniques to collect fouling community samples. Results of analysis of these samples were used to describe seasonal and areal variations in biomass, community composition and effects of effluents. Sampling sites were located on five structures in the BOF (Fig. 1). These were production (P) 288A, quarters (Q) 288A, production 296B, quarters 296B, and satellite (S) 288-5. Sampling sites on production and quarters structures were situated on support legs one each distal and proximal to an effluent discharge pipe. On the satellite structure a leg on two opposite sides was sampled. Legs were designated "east" or "west". Three depths--surface, midwater (8 m) and bottom (18 m)--were sampled on each leg. At each site, two methods were used to collect representative samples of the fouling community. In order to sample the mat and cryptic species portion of the community, a 4.8-cm diameter jar was held against the leg and the enclosed mat was scraped into the jar using a putty knife. Four jar samples were collected at each site. A larger sample size was used to collect the habitat formers (barnacles, molluscs) and larger invertebrates such as xanthid crabs. First a 25- x 25-cm metal quadrat template was secured to the platform leg and photographed. Fouling organisms enclosed within the template were then removed and placed in a plastic bag. The above collections are referred to as jar samples or template samples, respectively.

Sampling stations were selected to provide contrasts between control satellite structure (S 288-5) and structures with produced water, sewage, and heated water effluent discharges (288 and 296 production and quarters platforms). No effluent discharges were associated with the control station. Produced water discharges were located on the west sides of production platforms P 288A and P 296B. A heated water discharge was adjacent to the west leg of Q 288A while a combined hot water-sewage effluent spewed out adjacent to the east leg on Q 296B.

The original sampling array was to be performed in summer and winter at stations located on P 288A, Q 288A, and S 288-5. After the summer samples were collected the operators of the BOF changed the site of oil and gas processing from P 288A to P 296B. After these events were made known, the National Marine Fisheries Service (NMFS) changed the site of intensive sampling activities from P 288A and Q 288A to P 296B and Q 296B, respectively. The station S 288-5 remained as the control structure.

Samples collected by scraping were preserved in formalin and taken to the laboratory for processing and analysis.

Laboratory Methods

For each jar sample the following measurements and observations were made.

1. Total weight of sample.
2. Shell (= barnacle and molluscs) weight.
3. Percent cover of each major group composing the mat.
4. Species composition of cryptic species (polychaete, amphipods, etc.).
5. Numbers of individuals of each cryptic species.
6. Wet weight biomass of each cryptic species.

Total and shell (barnacle and molluscs) weight measurements were made after excess water in each sample was removed by suction using a Buchner funnel. Wet weights were measured to the nearest 0.1 g on a top loading balance. The percent cover of each major group which comprised the mat was estimated visually. After the above measurements were taken, each jar sample was examined under a dissecting microscope and all or an adequate subsample of the cryptic organisms were removed and placed in vials. Specimens were sorted to the lowest practical taxonomic level (usually species), counted and weighed by taxa to the nearest 0.1 mg on an analytical balance.

Total weights and shell (barnacles and molluscs) weights of template samples were measured after each sample was placed on a brass screen and agitated to remove excess water. Wet weight was measured using a top loading balance. After total weight was obtained, all of the mat was removed from the barnacle and the shell pieces by vigorously scraping with a wire brush. The remaining shells were weighed to obtain shell weight and the mat weight was estimated by the difference in total and shell weights. Prior to scraping to remove the mat, large motile species were sorted and enumerated to provide a gross characterization of the sample composition. For each sample, the number of occupied (live) and unoccupied (dead) barnacle shells was determined.

Once the count and weight data for the respective taxa were put in a tabular format, they were summarized using various diversity indices. The Shannon-Weaver index was selected as the best overall index of diversity because it is reasonably independent of sample size and normally distributed (Bowman *et al.* 1970). Collection data were tabulated by number of species and number of individuals, and the index was estimated following Pielou (1966a):

$$H'' = -\Sigma \frac{n_i}{n} \log_e \frac{n_i}{n}$$

where n_i is the number of individuals in the ith species and n is the total number of individuals in the collection.

One advantage of the Shannon-Weaver index is that it is possible to compare H" to its upper theoretical maximum. This measure is related to redundancy and can be used to measure dominance or how evenly numbers are allocated in species categories by comparison with the calculated maximum. The "evenness" index of Pielou (1966b) was calculated

$$J = \frac{H''}{H_{max}} = \frac{H''}{\log_e S}$$

in which $\log_e S$ is the maximum possible value of H".

Following Dahlberg and Odum (1970) the species richness aspect of diversity was calculated for each pooled sample:

$$D = \frac{S - 1}{\log_e N}$$

where S is the number of species and N is the number of individuals. This index is influenced by sample size.

Statistical Methods

Differences between stations for samples of the biofouling organisms were tested by analysis of variance (ANOVA) techniques. Total weight of the sample, non-shell weight, and percentage of the sample weight comprised of shell were each tested in a factorial design. Since the production and quarters platform sites were changed from summer to winter, each season's samples were tested separately. Seasonal comparisons were limited to the control satellite sampling stations, which did not change. The treatment effects for the summer and winter analysis included platform types (production, quarters, and satellite), side (east and west), and depth (surface, midwater, and bottom) and all possible interactions. The data were transformed for the analysis such that their distributions approximated normal. Variance to mean ratios for total weight and non-shell weight were approximately equal to one, indicating that these data were probably distributed as Poisson. Thus, these data were transformed by square-root (Steel and Torrie 1960). The percentage data were transformed by arcsin square-root (Steel and Torrie 1960).

Species diversity, evenness, and species richness data were also tested by ANOVA. The comparisons were essentially the same as for the weight data except that the highest order interaction terms were used to approximate error mean square since the diversity parameters were not calculated for individual replicate samples. No transformation of these data was necessary since diversity parameters are generally conceded to be approximately normally distributed (Bowman *et al.* 1970).

Cluster analysis techniques were used to explore associations between collecting sites and to elucidate species (taxa) associations. Cluster analysis involves the use of a dissimilarity measure to determine the degree of association between pair-wise combinations of data units based on some variables (Clifford and Stephenson 1975). In this application the data units were collecting sites and the variables were the number of specimens of each taxon. The clustering of sites based on species (taxa) composition is referred to as a normal analysis. An inverse analysis, clustering taxa based on the sites at which they were collected, was also performed. The Bray-Curtis dissimilarity measure was utilized for the analysis using a flexible sorting strategy with the cluster intensity coefficient set at -0.25 following the recommendations of Clifford and Stephenson (1975). To reduce the bias of a few disproportionately high values, a root transformation was performed on the catch data for the normal analysis. For the inverse analysis, a norm standardization was applied in addition to the root transformation. The results of the cluster analyses were displayed as dendogram, one for the normal and one for the inverse analysis. A two-way table was also produced to show the relationship between sites and taxa clusters. Using the dendograms and the two-way table, major clusters or groups were separated based upon the degree of dissimilarity and characteristics of the two-way table since no satisfactory statistical methods are presently available. Cluster analysis was performed using the program CLASS developed and installed at the Texas A&M University Data Processing Center by Dr. Robert Smith of the University of Southern California.

Recolonization Studies

The effect of the produced water discharge of P 288A on recolonization rates and community composition of the biofouling community was measured by collecting "new" growth of fouling organisms at varying time intervals. Four areas (25 X 25 cm) near the surface on the platform leg adjacent to the produced water discharge and on a west leg at S 288-5 were cleaned during summer 1977. At approximately 90-, 180-, and 270-day intervals, samples were collected with each area recleaned of fouling organisms. Three jar samples (collected by techniques described above) were taken from each quadrat, preserved in formalin and transported to the laboratory for analysis.

The measurements and analyses performed on the biomass jar samples as described above were also performed on the recolonization jar samples.

Estimation of Production Rates

Production rates of the biofouling community were calculated based upon seasonal changes in standing stock biomass. Data utilized included those collected as part of the biomass and diversity studies and those from the recolonization studies. Production rates were expressed as a daily change ($g/m^2/day$) in net production; i.e., grazing, growth and recruitment were included in the measurements.

Population and Movement Studies of Atlantic Spadefish

During August 1977, spadefish were captured using hook and line at each of platforms P 288A, Q 288A and S 288-5. Fish were marked using numbered streamer tags of surveyors' polyethylene flagging material. A different colored tag was used at each platform (P 288A = red; Q 288A = yellow; S 288-5 = white). As each fish was caught, it was measured for standard length, marked using a large sewing needle to insert the tag through the dorsal ptergiophores, and released at the platform of capture.

Each of the 9 structures in lease block 288 (P 288A, Q 288A, S 288-2, S 288-3, S 288-4, S 288-5, S 288-8, S 288-10, S 288-18) was censused by divers for marked and unmarked spadefish within a period of 1 to 5 days after the marking effort.

The winter mark and recapture effort occurred during February-March 1978. Spadefish were not susceptible to capture by hook and line and were marked *in situ* during February 2-27, 1978, using lances equipped with detachable barbed tags. Fish were marked at structures P 296B (yellow tags), Q 296B (red tags) and S 288-5 (white tags). The winter census effort was performed on 12 March 1978 at structures P 296B, Q 296B, S 296-1, S 288-18, P 288A, S 288-5, and S 296-12.

Population estimates were made based upon mark-recapture data gathered during summer which were believed to meet most of the following assumptions.

1. Marked and unmarked fish were randomly mixed.
2. Marked and unmarked fish experienced equal mortality.
3. Marked and unmarked fish were equally susceptible to recapture.
4. Tag loss did not occur.
5. Recruitment or emigration did not occur between marking and recapture sampling.

Of these, assumption 4 "Tag loss did not occur" was the one most likely violated during summer. Assumptions 4 and 5 were obviously violated during winter and population estimates were not made for that season.

Summer population estimates were made using the single census method expressed by Bailey's (1951) modification of the Petersen formula:

$$\hat{N} = \frac{M(C + 1)}{R + 1}$$

where M is the number marked and released; C is the number subsequently examined for marks; R is the number of marks contained in the sample and $\hat{N}$ is the population estimate. The addition of 1 to the C and R samples tends to reduce the bias associated with direct sampling. Confidence intervals were derived based upon the appropriate distribution determined from catch size (C) and recapture to catch ratio as described by Davis (1964).

Trophic and Condition Studies of Atlantic Spadefish

Feeding rate and periodicity determinations for spadefish based upon field experiments were attempted during August 1977; based upon the results from the summer sampling, only feeding periodicity studies were performed in winter 1978. In August, 43 spadefish were caught during a 41-min interval by hook and line and placed in a presumably food-free holding cage. Three specimens were sacrificed at time 0 and at 2-hr intervals over a 24-hr cycle. At each sacrifice time wild fish were also caught. Each sacrificed fish was weighed, measured, sexed, and the stomach was removed, preserved and transported to the laboratory for analysis. The progressive reduction of stomach contents among the caged fish was to be used to estimate evacuation time whereas the mean weight of stomach contents of wild fish was to be used to estimate feeding periodicity. In conjunction, these data would have allowed an estimate of feeding rates following Davis and Warren (1971).

The summer experiment was unsuccessful because, as described in the results section, (1) spadefish are not dependent upon the fouling community for food but are primarily feeders on zooplankton and suspended particulate material and (2) digestion or stomach evacuation did not occur for specimens held in cages.

During winter 1978, spadefish were captured by spear at different platforms and times of day in order to determine food habits and feeding periodicity. Each specimen was weighed, measured, sexed with the stomach removed, preserved in formalin and transported to the laboratory for analysis.

In the laboratory, the contents of each stomach were placed on filter paper, placed in a Buchner funnel and subjected to a suction to remove excess water. The contents were weighed to the nearest 0.1 g on a top loading balance. The stomach contents were placed in a petri dish containing water and examined under a dissecting microscope. Major taxa were identified and the weight of each component of the sample was estimated. A fullness index (see data analysis methods) was used to make comparisons of spadefish feeding behavior. The various length and weight observations were used to compare seasonal and areal condition of spadefish.

Length-weight relationships for spadefish were compared using analysis of covariance (AOCV) techniques (LeCren 1951). The technique as applied here consists of a general linear model theory lack of fit test (R.J. Freund, Institute of Statistics, Texas A&M University, personal communication) in which (1) the overall regression relationship was determined and tested, followed by (2) separate, yet parallel, relationships for each treatment, and finally (3) separate regression with unequal slopes. For our application, the third test tells us if the relationships are best described as separate regression equations. If this test indicates statistical significance, then standard AOCV techniques are not valid. If the third test is non-significant, then the second test tells us if the relationships are adequately described as parallel regression lines. If the second test is significant, then standard AOCV tests can be used. If it is not significant, then AOCV tests are unnecessary, and the first test of the lack of fit analysis becomes important because it tests for a single regression relationship over all treatments.

The length-weight relationship for fish has the general form

$$W = aL^b$$

where W is weight, L is length, and a and b are constants. In order to perform AOCV it is first necessary to linearize the equation. This is done by taking the logarithm of both sides of the equation. The linear equation then takes the form

$$\log W = \log a + b \log L$$

In this form the general model lack of fit tests can be applied and the intercept values being compared by AOCV are log a. In our graphic displays of the length-weight data for spadefish, we have plotted the data as log W - log L functions and presented the formulas in their original non-linear form; however, the tests were performed on the linearized formulas.

Feeding Rates and Periodicity of Barnacles

Estimates of feeding rates of barnacles were derived from literature review. Feeding periodicity was determined during winter by diver observation. Each of two divers selected a clump of barnacles at a depth of about 6 m for observation. Observations were made at 4-hr intervals over a 24-hr cycle and were of 5 min duration. Total number of barnacles in each clump was noted and the number of barnacles actively feeding during each observation period was recorded.

Respirometry Studies

A crude respirometer was constructed by fitting an acrylic plastic hemisphere (45 cm inside diameter) onto a wooden base contoured to fit and seal to a leg of the platform. Incurrent and excurrent apertures were fitted with hoses connected to a water reservoir on the lower deck of the platform. A dissolved oxygen probe and stirrer (Hydrolab Model 8002) connected to a surface readout unit were also fitted into the hemisphere. An area for the base of the respirometer was scraped clean leaving a circular patch of the biofouling community to be enclosed under the hemisphere. The respirometer was installed over this area by divers. Water was flushed through the system by gravity flow.

Once dissolved oxygen levels had stabilized, water flow was cut off and resulting oxygen declines were recorded until a minimal level of 2 ppm was reached. Water flow was then resumed. Day and night oxygen decay rates were obtained using seawater to represent a baseline, then a 25% solution of produced water in seawater was introduced into the dome via the fill reservoir. Winter and fall field sampling periods were devoted to designing and perfecting the apparatus; the produced water experiment was performed during March of 1978.

Field Services - Sampling

LGL divers were employed to deploy sediment traps and to collect bottom core and surficial sediment samples at 30 stations around structures P 288A and a satellite well for Work Units 2.4.1 and 2.4.2; 30 1-liter bottom water samples for Work Unit 2.4.1 and 7 suspended particulate samples from sediment traps for each of Work Units 2.3.7, 2.4.1 and 2.4.2. A total of 10 5-gal water samples were to be taken from the nepheloid layer for Work Units 2.4.1 and 2.4.2 on an opportunistic basis depending upon the presence and density of the layer. Samples were to have been taken during the period September-November 1977.

All contracted samples were obtained and transferred. Nepheloid layer water samples were not taken as the layer was not well defined during sampling periods. Due to problems related to adverse weather and equipment failure, the sediment trap sampling was not completed until Spring 1978.

Spadefish Disease Observations

A complete report describing observations and results of investigations concerning a spadefish disease epidemic in the Buccaneer Oil Field during the winter and spring of 1978 is included as Appendix I.

RESULTS AND DISCUSSION

During 1977-1978, the fouling community consisted of two main components, habitat formers and a fouling mat. The habitat formers included the large barnacle *Balanus tintinnabulum*, oysters (*Ostrea*, *Crassostrea*, *Isognomon*) and other bivalves. The fouling mat was dominated by red and green algae and hydroids at the surface stations; branching bryozoans, encrusting bryozoans and encrusting sponges at the midwater stations; and by encrusting sponges and bryozoans at the bottom stations. Some colonial ascidians and corals also comprised the mat at bottom stations. The cryptic species associated with the mat and habitat forming community were xanthid crabs (*Menippe*, *Hexapanopeus*, *Pseudomedaeus*, and *Pilumnus*), ophiuroids (*Ophiactis*), pistol shrimp (*Synalpheus*), amphipods (especially *Caprella*, *Corophium*, *Elasmopus*, *Erichthonius*, *Stenothoe*, and *Jassa*), tanaids (*Tanais*) and the numerous species of polychaetes. Similar organisms were reported to comprise the fouling community of Buccaneer Field structures by Fotheringham (1977).

Standing Stock Biomass and Diversity of the Biofouling Community

Results presented below are based upon the two types of scraping sampling employed. The "template samples" are believed to be more reliable as a basis for characterization of the overall biofouling community than are the "jar samples." However, the latter samples provide a basis for quantitative comparisons of fouling mat communities and associated microcryptic species.

Template Samples

In general, the total biomass of the biofouling community was highest at the surface and lowest at the bottom stations during both summer and winter (Figs. 2 and 3, Table 1). In summer, the total biomass at the station below the produced water discharge on P 288A was lower than at any other surface station (Fig. 2). At Q 288A, on the other hand, the total biomass was greater on the west or affected side than on the east side of the structure. The greater biomass may have been related to the enrichment of the water by the sewage discharge coming from the northeast side of the platform. Westerly currents could easily carry the enriched water to the west side of the small Q 288A platform and enhance the growth of both the habitat formers and the fouling mat.

A similar biomass distributional pattern was observed during winter but on different production and quarters platforms (Fig. 3). On the production platform, the shell and mat weights were noticeably greater on the unaffected leg of P 296B than on the affected leg (Production West Surface). At the quarters platform Q 296B, the shell biomass at the surface was greater on the east side than the west side. On this structure, hot water is discharged at the east leg which may have stimulated growth of the fouling community during winter periods.

A large percentage of the total biomass contained in the template samples was represented by shelled organisms (Table 1). Most of the biomass of these forms was represented by barnacles, particularly *Balanus tintinnabulum*. The total numbers of live and dead barnacles varied among platforms, depth and season (Table 2). During both summer and winter, barnacles were typically abundant to a depth of 8 m and, although represented, were generally scarce at bottom stations. With the exception of the surface station beneath the produced water discharge on P 288A the number of live barnacles exceeded the number of dead barnacles observed at all stations sampled during summer (Table 2). Beneath the produced water discharge of P 288A only 138 live barnacles were contained in the total sample of 2900 specimens. At the midwater stations, live specimens exceeded empty shells at all stations, and, at the bottom, the number of empty shells typically exceeded the number of occupied or live barnacles. Barnacles were particularly abundant at the midwater stations on Q 288A during the summer period as compared to the numbers at midwater stations on other structures. This area of barnacle abundance corresponded to areas receiving the discharge of treated sewage.

Many of the barnacles observed at surface stations during the summer season were small barnacles, particularly those of the affected, or west, leg of P 288A. Although only 5% of the small barnacles were alive at this station when sampled, some 2900 individuals had settled there. More barnacles probably settled in this area because more space was available for settlement. However, few individuals were able to survive at this station. The number of live barnacles at the surface on the east or unaffected side of P 288A during summer was six times greater than the number observed at the affected surface station. The produced water discharge may either (1) periodically vary in terms of toxic properties depending upon rates and amounts being discharged such that barnacle sets can occur during periods characterized by low-level contamination with survival time of individuals being a function of length of period of low-level discharge, or (2) the discharge may not contain contaminant loads high enough to prohibit settling but adequate to cause mortality under conditions of chronic exposure.

During winter, P 296B and Q 296B were sampled instead of the 288A structures. The produced water discharge from 288A had been routed to and discharged from the 296B structure since fall of 1977. The pattern of abundance of barnacles by depth was similar to that observed during summer, but overall abundance was generally much higher in winter than was observed during summer (Table 2; data for S 288-5 provides the primary basis of comparison). The barnacle *Balanus tintinnabulum* was reported to breed from April to December in California by Coe and Allen (1937). They also observed free swimming larvae at all times except winter.

Patterns of abundance and live-dead ratios of barnacles among the surface stations of structures sampled during winter differed from that observed during the summer. Live barnacles outnumbered dead barnacles in the surface area under the produced water discharge by a ratio of about 3 to 1; however, live dead ratios in other areas ranged from 6 to 16 to 1. Additionally, barnacles were more abundant at all other surface stations than the area beneath the produced water discharge. Pronounced abundance of barnacles at midwater stations on Q 296B were not observed.

Oysters, xanthid crabs, ophiuroids, and pistol shrimp were common in near-surface collections made during the summer at the platforms Q 288A and S 288-5 but were rare at the surface station beneath the produced water discharge of P 288A. In the winter, the effect of the discharge on the oysters and associated cryptic species was also apparent. Macrocryptic taxa apparently most affected during winter by the produced water discharge were the amphipods and the large polychaete worm *Neanthes succinea*. For example, at the surface station of the unaffected leg of P 296B almost 500 *N. succinea*/m^2 were recorded. In contrast, samples taken at the surface on the affected leg contained less than 100 *N. succinea*/m^2 (Fig. 4). Similarly, there were at least 20,000 large amphipods/m^2 at the unaffected station, whereas beneath the brine discharge only 500 amphipods/m^2 were collected.

As noted above, the satellite jacket S 288-5 was the only structure of the three sampled where the location was not changed from the summer to winter, thus permitting the comparison of the seasonal changes in biomass of the fouling community. The total biomass was highest at the surface and midwater stations in both summer and winter due mainly to the abundance of barnacles and other shelled organisms (e.g., bivalves). The biomass was lowest at the bottom stations during both seasons where there were few shelled organisms. Although barnacles settle near the bottom on the platform legs, they apparently die a short time later (Gunter and Geyer 1955).

Jar Samples

The jar replicates were relatively consistent. The occasional large variations among the jar samples can be attributed to the presence or absence of barnacles, and the size and composition of the mat (e.g., different species of sponges and/or the presence of a thick layer of encrusting bryozoans).

Biomass. During summer, small barnacles comprised most of the biomass of jar samples taken at surface stations, whereas at the midwater (8 m) and bottom (18 m) stations, the fouling mat comprised most of the weight (Table 3). The values representing the non-shell weight in the samples were similar among surface and midwater stations, but significantly greater at the bottom than in upper water column zones (Table 4). The unusually high mat weights at the bottom stations on the west legs of Q 288A and S 288-5 structures were due to a thick layer of sponge growing over a layer of encrusting bryozoans.

In general, the east side of the structures had a significantly lower non-shell weight than the west side (Tables 3 and 4). This relationship was pronounced for structures Q 288A and S 288-5, but on P 288A the west leg had a lower mat weight than the east leg resulting in the significant platform by side interaction. Values for total weights contained in the jar samples were significantly greater on the west side of the structures than on the east side. Total weight values were also significantly higher at the surface than at the bottom and significantly higher at the bottom than at the midwater stations (Table 5). Total weight was higher at the surface station beneath the produced water discharge of P 288A than at all other surface stations.

Results from the study of the percent cover of the major taxa comprising the mat from the jar samples collected during summer showed that the most abundant mat organisms at all depths were the encrusting sponges (Table 6). The hydroids were most commonly associated with bottom stations, the branching bryozoans with midwater stations, and the algae were characteristic of surface stations. Often there was a thick layer of encrusting bryozoans covered by sponges. Additional components of the fouling mat were colonial ascidians and corals. The produced water discharge had no apparent effect on the relative percent cover of the various taxa comprising the mat.

In winter, barnacles again made up most of the weight of the surface jar samples, while the mat comprised most of the weight at midwater and bottom stations (Table 7). The non-shell biomass was significantly greater at S 288-5 than at P 296B and Q 288A platforms, which were characterized by similar biomass levels (Tables 7 and 8). The weights were significantly different between the east and west sides of the platforms and among the depths. The significant differences observed for platform by side and platform by depth interactions were probably the result of the unusually high non-shell weight at the midwater station on the west side of S 288-5. The total weight value for S 288-5 was significantly greater than that for Q 296B which, in turn, had a significantly greater mat biomass than did P 296B (Tables 7, 8, 9). There was no significant difference in total weight between the sides. Total weight values were significantly greater at surface stations than at bottom stations. The significant platform by side and platform by depth interactions (Table 9) were probably the result of the high biomass observed at the midwater station on the west leg of S 288-5.

Statistical analysis was performed on the non-shell weight and total weight values using data from jar samples collected at S 288-5 in the summer and winter in order to evaluate season as a factor. The non-shell weight values were (1) significantly greater in the winter than in the summer, (2) significantly greater on the west side of the platform than on the east side, and (3) significantly greater at the midwater stations than at the bottom and surface stations (Table 10). The significance of the season by depth interaction for non-shell weight values can be attributed to a greater non-shell weight at the bottom in the summer, whereas it was greater at the midwater level in the winter. The total weight values were also significantly greater in the winter than in the summer (Table 11). Values were significantly greater on the west side than on the east side and significantly greater at the surface than at the midwater level. Total weight levels at midwater stations were significantly greater than levels recorded at the bottom (Table 11). The total weight values were higher at the bottom than midwater stations in the summer, whereas they were greater at the midwater than bottom stations in the winter. These differences contributed to the significance of the season by depth interaction shown in Table 11.

Increases in the total weight and the non-shell weight of the fouling community in the winter have been reported by others. McDougall (1943) observed an increase in the number of barnacles on pilings in the winter. Coe and Allen (1937) recorded an increase in hydroids, oysters, and serpulids in the autumn. Gunter and Geyer (1955) reported that the fouling growth was heaviest in the winter in Louisiana.

The percent cover of the mat oragnisms in the winter is shown in Table 12. The encrusting sponges were the dominant members of the mat community in the winter as well as in the summer. McDougall (1943) reported that sponges were common during all seasons. Hydroids were more abundant at the surface and midwater stations in the winter than in the summer. Algae were more prevalent at the surface in the winter than during summer. At the midwater stations the branching bryozoans predominated to the extent that they excluded the other mat formers. The colonial ascidians, corals, and amphipod tubes were important components of the mat community at some stations in the winter.

Densities and Diversity. Data describing numerical and biomass densities and diversity of microcryptic organisms contained in the summer jar samples are shown in Tables 13-18. During summer, samples collected at each depth on the west legs of structures Q 288A and S 288-5 were characterized by a greater numerical density of organisms than was observed at the respective depths on the east legs of these structures (Fig. 5). In contrast, samples from each depth on the west, or produced water discharge, leg of P 288A were characterized by lower densities of organisms than were observed at the same depths on the east side of this structure. Additionally, density levels at each depth sampled on the leg beneath the produced water discharge were lower than densities at each respective depth on the west leg of the other two structures (Fig. 5). Total density of microcryptic organisms appears to have been inhibited at all depths in the immediate vicinity of the produced water discharge. The above described trends are particularly evident when the depth data are integrated to provide a comparison of density levels between east (non-affected) and west (affected) legs of the respective platforms (Fig. 6). The similarity of density levels of microcryptic organisms at structures Q 288A and S 288-5 (Fig. 6) suggests little or no effects resulted from the discharges of treated sewage and warm water at Q 288A during summer.

Comparisons of species diversity levels based upon numbers of organisms (H") are shown in Fig. 7. On each leg of structure P 288A, diversity was lowest at the bottom and lower at the surface stations than at midwater stations. Diversity levels were generally lower at all depths on the west leg than on the east leg. On the west leg of Q 288A, diversity increased with depth whereas on the east leg, diversity decreased with depth. Diversity levels also decreased with respect to depth on the west leg of S 288-5. On the east leg of this structure, the highest diversity of microcryptic forms was observed at the bottom station and the lowest level was found at the midwater station. Results of analysis of variance performed on each of the three diversity indices calculated based upon numbers (H", J, D), indicated there were no significant differences among platforms, locations, depth or interactions (Tables 19-21).

The numerically dominant microcryptic forms contained in the summer jar samples were nematodes, the polychaete worms *Haplosyllis spongicola* and *Synsyllis longigularis*, and the tanaidacean *Tanais* sp. (Tables 13-15). The nematodes were 2.5 times more abundant at the surface station directly beneath the produced water discharge than at the surface station on the east leg of the structure (Fig. 8). Additionally, the numbers of individuals of *H. spongicola*, *S. longigularis* and *Tanais* sp. were greatly reduced at the surface beneath the produced water discharge as compared to all other areas. The discharge apparently adversely affects the two polychaete worms and the tanaid, whereas the nematodes may be beneficially affected. The abundance of the nematodes beneath the produced water discharge might be explained by their resistance to factors toxic to other animals and by their general adaptability (Meglitsch 1972). Their abundance beneath the discharge also may have been due to the increase in the available habitat as a result of the decrease in the number of the other members of the fouling community.

Biomass data for microcryptic organisms associated with the summer mat community were determined (Tables 16-18). In summer, the dominant organisms in terms of weight were the ophiuroid *Ophiactis savignyi*; the crabs *Menippe mercenaria* and *Pseudomedaeus agassizi*; the bivalves *Ostrea equestris*, *Anadara transversa*, *Chama macerophylla*, *Isognomon bicolor*; and the large polychaete *Lumbrineris coccinea*.

Generally, biomass levels were variable at the different locations and depths and showed no consistent trends (Fig. 9). Much of this variability is attributable to the presence of rare, large-weight taxa in some of the samples. For example, one specimen of the crab *Hexapanopeus paulensis* accounted for 87% of the total weight of organisms at the surface station on the west leg of P 288A. At the surface on the west leg of S 288-5, one individual of the bivalve *Anadara transversa* and a clump of ophiuroids accounted for almost 60% of the total weight. The problems with the large-weight, rare organisms in the jar samples would be alleviated by using a larger sample size, a sampling feature incorporated in the ongoing studies. To offset problems associated with the small samples of last year's program, the composite of all samples taken from a given leg of each structure were combined to represent a single sample (Fig. 10). Biomass was lowest on the west side of P 288A proximal to the brine discharge (Fig. 10). At the other platforms the biomass was greater on the west side than on the east side.

Comparisons of species diversity levels observed in summer based upon weight distribution in composite samples (H''_w) are shown in Fig. 11. In general, levels of H''_w on both P 288A and Q 288A were higher at midwater stations than at surface and bottom station. On P 288A, diversity levels at the surface and midwater stations of the affected leg were lower than diversity levels at the same depths on the east leg. In contrast, on structure Q 288A, diversity levels were higher on the west than on the east leg throughout the water column. At the satellite well (S 288-5) diversity levels varied little by location or depth. Diversity levels associated with P 288A were typically lower than levels associated with the other structures. Results of analysis of variance (Tables 22-24) showed these differences were statistically significant.

The relative biomass distribution for the summer-season numerical dominants at surface stations is shown in Fig. 12. In terms of weight, *Synsyllis longigularis* dominated most surface collections, but *Tanais* sp. was also well represented. *Haplosyllis spongicola* was conspicuous in its absence at the surface station beneath the produced water discharge (Fig. 12).

Numerical data describing the summer microcryptic fauna were subjected to cluster analysis to better define station and species associations (Figs. 13-15). Stations clustered into three major groups with the highest degree of dissimilarity existing for Group I (P 288A East Bottom, P 288A West Bottom, Q 288A East Bottom) versus the other two groups (Fig. 13). Group III contained a single station, that at the surface beneath the produced water discharge of P 288A. Group II contained all the remaining stations. Subsets of stations contained within Group II clustered remarkably well by depth. We considered the data to show four taxonomic associations (Fig. 14). The station by species associations are shown in Fig. 15. Group 1 contained taxa found almost exclusively at one location at the bottom stations. Group 2 was characterized by organisms that were relatively rare and also occurred mostly at bottom stations. Group 3 included both common and rare taxa which were collected at various depths and platforms. Group 4 contained rare taxa which were almost exclusively found at the surface station beneath the produced water discharge at P 288A. We consider the results of the cluster analysis to conclusively demonstrate effects of the produced water discharge on the microcryptic fauna in the summer season. Marked effects of the liquid discharges from Q 288A were not indicated based upon the results of cluster analysis.

Numbers and biomass of microcryptic organisms collected during winter 1977-1978 are shown in Tables 25-30. With the exception of the surface station beneath the warm water sewage discharge on Q 296B, where density was high, numerical densities on the production and quarters platforms 296B were markedly lower than densities observed at the control structure, S 288-5 (Figs. 16 and 17). These differences are particularly apparent at surface and midwater depths; little difference in numerical densities was observed among bottom stations (Fig. 16).

Species diversity levels of the microcryptic fauna based upon numbers were inversely correlated to abundance during winter; i.e., stations with low diversity were characterized by high numbers of the seasonally abundant amphipods. In contrast to the summer data, species diversity (H_n'') was typically higher at affected structures (P 296B, Q 296B) than at S 288-5 (Fig. 18). Results of analysis of variance tests performed on these indices indicated significant differences for all parameters tested (Table 31). Structures P 296B and Q 296B had a significantly greater species diversity than did S 288-5. The west sides of the platforms were characterized by significantly greater diversity levels than were the east sides. Diversity at the bottom was significantly greater than that at the midwater level which, in turn, was significantly greater than that at the surface. The significant platform by side interactions were probably caused by the differences in diversity at Q 296B midwater and bottom stations on the west leg. The diversity at these two stations was lower than at the same depths on the east side of the platform, whereas at the structures P 296B and S 288-5 there was relatively little difference in diversity levels between sides at the midwater and bottom stations. The significant platform by depth interactions were probably the result of the lower species diversity observed at the Q 296B surface and midwater stations on the west leg, whereas at the production and satellite structures the diversity at Production West Surface and Satellite West Surface stations was greater than diversity at the midwater stations on the same side. The significance of the side by depth interactions was the result of the high species diversity at the west side surface stations of P 296B and S 288-5, whereas at the other surface stations, diversity was lower at the surface than at midwater stations. The variations in the H_n'' index were more influenced by the evenness component (Table 32) than by the richness component (Table 33).

The dominant organisms, in terms of numbers of individuals, at the surface stations during winter were the amphipods *Jassa falcata*, *Caprella equilibra*, and *Stenothoe gallensis* (Fig. 19A). These three amphipods appear to have been severely affected by the produced water discharge as they were rare or missing at the station below the outlet. At Q 296B, the surface sample beneath the combined sewage and hot water discharge contained a much greater number of these amphipods than any other surface station of the affected platforms. At the control station, S 288-5, different species were dominant on each of the east and west legs. Observations of the effect of the produced water discharge in the winter on the taxa that were dominant in the summer (Nematoda, *Synsyllis longigularis*, and *Tanais* sp.) indicated that the produced water discharge also affects these species in the winter (Fig. 19B).

Biomass data for microcryptic organisms associated with the winter mat community were also calculated (Tables 28-30). Each of the three structures was characterized by a different set of microcryptic organisms. At P 296B, the biomass dominants were *Neanthes succinea*, *Caprella equilibra*, *Jassa falcata*, and the solitary Ascidian sp. 1 (Table 28). At the Q 296B platform the dominant organisms by weight were the polychaete worms *Autolytus* sp. 2 and *Synsyllis longigularis*; the amphipods *Caprella equilibra*, *Jassa falcata*, and *Stenothoe gallensis*; and the bivalves *Isognomon bicolor*, *Lithophaga bisculata*, and *Musculus lateralis* (Table 29). At S 288-5, the dominants by weight were Anemone sp. 2; the polychaete *N. succinea*; the amphipods *C. equilibra*, *Corophium* sp., *Erichthonius brasiliensis*, and *J. falcata*; the bivalves *Chama macerophylla*, *I. bicolor*, *M. lateralis*, and *Pteria colymbus*; and the ophiuroid *Ophiactis savignyi* (Table 30). Many of these dominants were represented by relatively few individuals which, nevertheless, comprised a significant amount of the total sample weight because of either (1) their large individual size (e.g. *N. succinea*) of (2) because of their thick shells (e.g. the bivalves). The bivalves made up a large portion of the total biomass collected at the surface on the west sides of structures Q 296B and S 288-5 but were insignificant weight components of samples taken beneath the produced water discharge on P 296B.

With the exception of the bottom stations where biomass levels were about equal among all the platforms sampled, biomass was greater at stations on the control structure (S 288-5) than at stations on structures P 296B and Q 296B (Figs. 20 and 21). Biomass of microcryptic taxa was particularly low on the production platform and on most areas of the quarters platform. In the latter case, biomass levels at both surface stations and the midwater station beneath the warm water discharge were relatively high (Fig. 20) suggesting an impact of the discharge.

Winter values for species diversity indices based upon weight (H''_w) are compared by platform type, proximity to discharges, and depth in Fig. 22. Generally, diversity increased with depth at all three platforms. At P 296B the increase from surface to midwater depths was particularly pronounced. The differences in diversity between surface and deeper areas were statistically significant (Table 34) as was the same contrast for evenness values (Table 35). Values of species richness at bottom stations were also significantly higher than at upper water column stations (Table 36).

Results of the cluster analysis performed on the winter count data are displayed in Figs. 23-25. With the exception of both midwater stations on S 288-5, all stations clustered by depth groupings. Surface stations were more dissimilar from midwater and bottom stations than midwater stations were from bottom stations. Within the surface station grouping the station beneath the produced water discharge was most dissimilar (Fig. 23). The midwater stations divided into two major groups. One of these consisted of the stations at P 296B and Q 296B, both of which were more similar to bottom stations than to the midwater stations on control structure S 288-5. Four species associations were indicated from results of the cluster analysis (Fig. 24). Of these, two of the groups were small and consisted of rare species collected at only one midwater station (Fig. 25). The other two groups consisted of species either common throughout the water column or common at both midwater and bottom stations.

Data for S 288-5, the only structure sampled both seasons, were used as a basis for seasonal contrasts of diversity (Tables 37-42). Based upon indices calculated from numerical data, significant differences were indicated for only the evenness index (J); species diversity and richness values were similar between seasons. Evenness was lower in winter than in summer due to the seasonal abundance of amphipods. No significant differences between seasons were indicated for any of the three indices derived from biomass distribution.

The numerically dominant organisms colonizing BOF structures changed with season. In the summer, the dominants were the polychaete worms *Haplosyllis spongicola* and *Synsyllis longigularis*; the tanaidacean *Tanais* sp.; and the nematodes. McDougall (1943) reported polychaetes were abundant in the summer in North Carolina. In the winter, the dominant organisms in terms of numbers were the amphipods *Jassa falcata*, *Caprella equilibra*, and *Stenothoe gallensis*. Thomas (1976) noted that amphipods dominated his trawl samples from October to March in Louisiana, and *Caprella* sp. was observed to be abundant in the winter in North Carolina (McDougall 1943).

Other organisms that were abundant in the winter included the amphipod *Corophium* sp., nudibranchs, solitary ascidians and nemerteans. Nudibranchs and ascideans have been reported to be common in the winter in North Carolina (McDougall 1943). *Corophium* sp. has been reported as abundant in Louisiana during winter (Gunter and Geyer 1955). The amphipod *Erichthonius brasiliensis* was very abundant at the satellite jacket but was rare at the other structures. Coe and Allen (1937) observed thousands of individuals of this species on a single 8-in X 9-in plate in their California study during one year.

Recolonization Studies

Seasonal samples were taken from near-surface areas beneath the produced water discharge on P 288A and on the west leg of S 288-5 to evaluate the effects of the produced water discharge on recolonization rates of the biofouling communities. These sites had been scraped clean in summer 1977. The samples for which data are available for inclusion in this report are intended to characterize the recolonization that occurred at each site for the periods (1) summer to fall, (2) fall to winter, and (3) summer to winter. In this section only the microcryptic taxa are discussed. Total biomass, barnacles, and the fouling mat are discussed in the following section on gross production.

During the summer to fall period, a total of 1,033 specimens weighing a total of 68 g and representing seven microcryptic taxa were contained in the samples taken beneath the produced water discharge (Tables 43 and 44). At S 288-5, 722 individuals weighing a total of 163.1 g and representing 14 taxa were collected (Tables 43 and 44). Relative abundance of the dominant species in terms of numerical and biomass densities are depicted in Figs. 25 and 27. In terms of numbers, nematodes and *Tanais* sp. dominated P 288A summer-fall recolonization samples, whereas *Jassa falcata* and *Tanais* sp. were numerical dominants at S 288-5. Most of the biomass in P 288A samples was represented by a single species (*Tanais* sp.). The biomass dominants recruited at the control, S 288-5, were the amphipod *Jassa falcata*, the isopod *Dynamene* sp. and *Tanais* sp.

Data for samples collected from areas cleaned in fall and allowed to recolonize through the end of winter showed that more individuals and a greater biomass had settled on S 288-5 than on P 288A (Tables 45 and 46). Nine taxa were represented at each sample site. Dominants (numerical and biomass) were the same for each station (Figs. 26 and 27).

Data collected for areas allowed to recolonize for the entire summer to winter period more resembled data for the second quarter than the first quarter (Tables 43-48). Both numerical and biomass densities were high as compared to summer to fall densities, particularly at the control structure S 288-5. Only six taxa were represented at the station beneath the produced water discharge, 16 taxa were represented in samples from S 288-5. Numerical dominants were the same for each platform but the biomass dominants were considerably different (Fig. 26 and 27). The amphipod *Caprella equilibra* dominated biomass samples for P 288A whereas *Jassa falcata* and the bivalve *Isognomon bicolor* comprised most of the weight at the S 288-5 structure (Fig. 27).

In general, recolonization samples from the control structure S 288-5 were characterized by greater biomass and numerical densities, number of taxa and species diversity than samples taken in the area of discharge at P 288A.

Gross Seasonal Production

Gross seasonal production in grams/m^2/day also was estimated for the fouling community from template, jar, and recolonization samples collected at the satellite jacket (Table 49). Similar information could not be obtained for the template and jar samples collected at the production and quarters platforms since these structures were altered between the summer and winter sampling period. Comparison of production between summer and winter at the surface stations of the satellite jacket showed that the highest production occurred at the sites cleaned and allowed to recolonize (62 grams/m^2/day). These results were expected since most species preferentially settle on clean substrates (Boyd 1972).

Estimates of the gross seasonal production that occurred on both the east and west legs of the S 288-5 structure at each of the three depths also were made (Table 49). The total production was greater at the midwater sampling stations than at the surface stations. Several factors may have contributed to the greater production in midwater areas. There should have been less competition for space at the midwater stations than at the surface, enabling organisms to grow more rapidly. The algae, which commonly overgrow and kill the barnacles at the surface, were less common at the midwater stations probably due to light reduction. The mat production also was greater at the midwater than at surface stations. The reduction in algae cover at midwater depths probably enables rapidly growing mat organisms such as sponges and bryozoans to establish themselves. At the bottom stations production values were negative indicating mortality was higher than recruitment at this depth between summer and winter.

Based upon the recolonization data, production rates differed between summer to fall, fall to winter, and summer to winter periods (Table 49). Production of barnacles was lowest during the fall to winter period, indicating that barnacle spawning did not occur during that period.

The effect of the produced water discharges on production can be deduced from the recolonization data. It must be noted that in the late autumn produced water was no longer released at P 288A, probably affecting the results. However, during each of the recolonization periods, gross production (g/m^2/day) was much less at the production platform than that observed for S 288-5 illustrating the adverse effect of the brine discharge.

Population and Movement Studies of Atlantic Spadefish

Results from mark and recapture studies of Atlantic spadefish performed over an 8-day period in August indicated this species was relatively "habitat faithful," at least over the short term. A total of 344 fish were marked at the three study platforms and all platforms in lease block 288 were censused by divers several days after the marking period. Of the 16 to 18 marked fish observed during the census, only two were found in a location other than where they were marked. One fish had moved from the quarters platform to the nearby production platform; another had moved about 0.6 km from the production platform to a satellite jacket. These data provide the following population estimates.

	P 288A	
	Diver 1	Diver 2
Marked (M)	226	226
Catch (C)	138	175
Recapture (R)	8	8
R/C	0.06	0.05
N	3,490	4,420
Distribution	Poisson	Poisson
95% Confidence Interval	1974-9173	2503-11,632

	Q 288A	
	Diver 1	Diver 2
Marked (M)	93	93
Catch(C)	92	46
Recapture (R)	3	2
R/C	0.03	0.04
N	2162	1457
Distribution	Poisson	Poisson
95% Confidence Interval	972-14,260	594-21,390

	S 288-5	
	Diver 1	Diver 2
Marked (M)	25	25
Catch (C)	89	115
Recapture (R)	7	6
R/C	0.08	0.05
N	281	414
Distribution	Poisson	Poisson
95% Confidence Interval	155-795	219-1307

Population size was directly proportional to size of structure. Density estimates of Atlantic spadefish at each structure were similar. Based upon the maximum estimates, density values by platform type during summer were (1) production platform, 0.15 fish/m^3; (2) quarters platform, 0.20 fish/m^3; and (3) satellite jacket, 0.13 fish/m^3. Atlantic spadefish at the satellite jacket were significantly smaller than those at the production and quarters platforms.

In February 1978, 509 Atlantic spadefish were marked *in situ* by divers in the Buccaneer Oil Field; 262 at P 296B, 148 at Q 296B and 99 at S 288-5. Because of the long interval between marking and recapture periods and the collection of 9 white tags from the bottom beneath S 288-5, the data obtained from the winter experiment were considered inadequate as a basis for population estimates. Sightings of marked fish during the census effort indicated the same movement trends during winter as observed during summer. Of the 45 marked fish observed during the census effort, one had moved the short distance from Q 296B to P 296B, and three marked at Q 296B had moved to P 296B. No other marked fish was sighted at a structure other than where they were marked. Atlantic spadefish appear to be habitat faithful during both summer and winter seasons.

Trophic and Condition Studies of Atlantic Spadefish

Food habits and feeding periodicity of Atlantic spadefish during August were determined based upon specimens captured over a 24-hr period by hook and line. If catch success can be equated to feeding activity, feeding was greatest during morning through mid-day (Fig. 28). No fish were caught during the period 2300 to 0300 hrs. The index of fullness values (F.I. = stomach contents (g) X 10,000 ÷ weight of fish (g)) for specimens angled in August were low (Fig. 29). Peaks of fullness were observed for specimens caught at 1900 (F.I. = 15.5) and 0900 (F.I. = 14.8) hrs. Values of FI ranged from about 8-12 during mid-day to late afternoon and stomachs were either empty (or near empty) or fish were not caught during the period 2100 to 0500 hrs. During summer, spadefish mainly fed during the daylight hours with peaks of feeding occurring in late afternoon and mid-morning.

Results of food habits analysis performed on samples collected during summer showed this species was primarily a feeder on plankton (averaged 35.55% of total weight of stomach contents) and barnacle moults (28.5%). The weight of unidentified materials in the stomachs represented about 36% of the sample weights. Aside from the barnacle moults which were abundant in the water column during summer, none of the summer abundant representatives of the fouling community were found to be of direct importance to Atlantic spadefish as food.

During the winter sampling period, Atlantic spadefish were collected for food and feeding determinations by spear to avoid the possible bias resulting from sampling by angling. Samples were collected at structures P 296B, Q 296B and S 288-5 during morning, mid-day and afternoon periods. Results of these efforts are summarized in Table 50.

Index of fullness values were relatively high for morning samples (average was 28.5), increased to an average of 58.5 by mid-day and values for afternoon samples were low (average FI - 5.4). The weight of the stomach content samples during morning and mid-day periods were strongly dominated by the hydroid *Tubularia crocea* (Table 50); most of the materials contained in the afternoon samples were not identifiable. We interpret these data to indicate that, during winter, spadefish feeding peaks occur during morning. The hydroid that comprised the principal food of the fish during the winter sampling period was abundant in the water column. This hydroid had been abundant on the structures during winter but, due to seasonal stress associated with warming water temperatures, large clumps of colonies were breaking loose from the structures and were suspended in the water column during the sampling period. Atlantic spadefish appear to be more dependent upon particulates and plankton suspended in the water column for food than upon the fouling community attached to the structures.

The size distribution of specimens comprising the basis for length-weight regressions and resulting comparisons of condition of fish by season and structures are shown in Fig. 30. Small fish (<230 mm long) were well represented in summer samples but were absent from winter samples. Conversely, large fish were obtained during winter but not during summer.

During summer the length-weight relationships of both male and female spadefish collected at P 288A were similar (Figs. 30-31). Results of the analysis of covariance test indicated no significant differences in condition between sexes during summer. The length-weight regression for sexes combined was $W = 0.000226L^{2.65}$ (Fig. 33). During winter, samples for comparisons of condition were collected from each of three platforms: P 288A, Q 288A and S 288-5. Again, results of analysis of covariance indicated that the length-weight regression for males (Fig. 34) was not significantly different from that for females (Fig. 35) such that the data could be represented as a single regression (Fig. 36).

The seasonal data representing condition of Atlantic spadefish (sexes pooled, Figs. 33 and 36) were contrasted using an analysis of covariance test. Results of this test indicated that fish in summer were characterized by significantly ($P = 0.05$) better condition than in winter. As seasonal size distributions were different, analysis of covariance was performed on the seasonal length-weight data using only the overlapping length ranges. Results indicated no significant differences in condition of similar size Atlantic spadefish between seasons. It should be noted, however, that condition of spadefish during winter as measured by frequency of disease was typically poor (see Appendix I).

Length-weight data gathered during winter enabled a comparison of spadefish condition among the three platforms (Figs. 37-39). Results of analysis of covariance indicated observed differences were not significant at the 5% level. As described in Appendix I, Atlantic spadefish populations at P 296B during winter were characterized by a greater frequency and severity of disease than the population at Q 288-5.

Feeding Rates and Periodicity of Barnacles

Feeding in barnacles involves extending their cirri and scooping up food particles. The particles suspended in the water are trapped by the setae and transferred to the mouth by the maxillae (Barnes 1963). Adult barnacles feed on a wide variety of organisms ranging from 2 µ to 1 mm in size (Southward 1955). Two types of feeding mechanisms occur in barnacles, captorial feeding of the larger particles, and microphagy of the smaller organisms (Crisp and Southward 1961). Among the organisms eaten by barnacles are bacteria, diatoms, peridineans (dinoflagellates), gastropod ova, foraminifera, barnacle nauplii and cypris larvae, small copepods, larval echinoderms and small gastropods (Southward 1955; Barnes 1959). The food eaten by barnacles varies with the environment as they generally eat what is available (Barnes 1959). However, there is some selection of larger food particles (Crisp 1964). An adult barnacle can filter 2 to 15 ml of water per hour (Southward 1955; Crisp and Southward 1961; Crisp 1964; Ritz and Crisp 1970). Approximately 1.5 mg of food (dry weight) is ingested per day during the growing season (Ritz and Crisp 1970). Digestion takes 10 to 12 hours at 12 to 16° C and 2 to 3 hours at 27 to 28° C (Svirenko 1961).

Variations in feeding activity occur with the habitat. The length of time the cirri are held open increases with current velocity (Crisp and

Southward 1961). Diurnal variations in feeding are also expected to occur since there is a greater concentration of zooplankton in the surface water at night as a result of vertical migration (Longhurst 1976).

In the Buccaneer Oil Field, barnacles were observed at approximate 4-hr intervals over a 24-hr cycle to determine the frequency of feeding activity Each of two divers delineated a clump of barnacles at a 20-ft depth containing 15 barnacles. These clumps were observed for a 5-min observation period at each sampling time. During the night (samples were taken at 1920, 2302 and 0301 hrs) the percent of barnacles demonstrating feeding behavior ranged from 40 to 60. At 1450 hrs, only 3% were feeding and at both 0707 and 1047 hrs, 13% of the barnacles observed were feeding. Feeding periodicity was highest at night.

Respirometry Studies

Results of the respirometry studies are depicted in Fig. 40. During both night runs, levels of dissolved oxygen in the respirometer decreased steadily at a rate of 0.58 mg/l per hour. At night, respiration would be expected to be higher than production. The control day run was performed during the period 0800 to 1232 hrs. Dissolved oxygen levels in the respirometer dropped 0.6 mg/l during the first 1.5 hrs, then stabilized at 3.5 to 3.6 mg/l. The resulting rate of dissolved oxygen decline was 0.18 mg/l per hour. Following the initial drop, production of dissolved oxygen appeared about equal to respiration or other oxygen-consuming factors. When the dome was filled with a solution consisting of 25% produced water, the waters inside became quite murky. Dissolved oxygen dropped 0.7 mg/l within 15 min of the introduction of the treatment solution and steadily declined until the experiment was terminated. The overall rate of decline was observed to be about 0.42 mg/l per hour. More oxygen was consumed than produced.

During this year's studies, experiments of this nature will be continued. The biomass of the community exposed will be collected after the initial experiment and the procedure will be repeated on bare pipe. It is believed that the experiments as designed for this year will enable us to evaluate the effects of produced water on respiration and production attributable to the fouling community.

SUMMARY OF FINDINGS

The produced water discharge had adverse effects on the fouling community over at least a limited area. Evidence of adverse effects included typically low densities and biomass of most fouling organisms, low survival rates of barnacles, low rates of production and low rates of recolonization. Results of cluster analysis indicated community structure in the area beneath the produced water discharge differed greatly from community structure observed in other areas. The discharge of warm water sewage from the quarters platform appeared to stimulate growth and production of near surface biofouling communities.

Biomass of the fouling community was considerably higher in winter than in summer. Recolonization rates of microcryptic forms during the fall to winter and summer to winter periods were higher than the rates observed for the summer to fall period. Gross seasonal production of the fouling community during the summer to winter period was estimated to range from 29 to 39 g/m^2 per day at the surface, 36 to 85 g/m^2 per day at midwater depths, and 4 g/m^2 per day at the bottom.

Results from mark and recapture studies of Atlantic spadefish indicated summer densities ranged from 0.13 to 0.20 $fish/m^3$, and population size was correlated to structure size. Marked spadefish were most often observed at the location where they had been marked; they were observed to move only short distances. Spadefish were determined to be dependent upon plankton and suspended particulate matter for food. Although condition was not observed to be significantly different between summer and winter periods, spadefish populations in the Buccaneer Oil Field suffered a disease epidemic during winter.

Barnacles in the Buccaneer Oil Field were observed to feed mainly at night. Based upon literature review, individual barnacles ingest about 1.5 mg of food per day during the growing season.

Produced water was observed to greatly increase oxygen consumption rates when introduced into an *in situ* respirometer. The size of the area impacted by produced water was not determined during this year's studies but will be addressed by ongoing studies being currently performed in the Buccaneer Oil Field.

That the produced water had any measurable impact was both surprising and disturbing. The effluent was characterized by low levels of contaminants (see results of Work Unit 2.4.1 and 2.4.2) and low discharge rates (about 95 m^3/day). Dilution of the stream was rapid. Using salinity and temperature as indicators (discharge values were as much as 5 to 10 C and 25‰ higher than ambient, respectively) the effluent could seldom be detected in the water column even at the point of discharge. Priority research should include determination of area of impact from the discharge and identification of toxic factors. Chronic effects of the produced water discharge based upon *in situ* observations indicate more impact than was expected based upon the results of bioassay.

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APPENDIX I.

OBSERVATION AND DIAGNOSIS OF DISEASED SPADEFISH IN THE BUCCANEER OIL FIELD

INTRODUCTION

During the course of our late-winter and early spring sampling in the Buccaneer Oil Field (BOF) for Work Unit 2.3.8 Effects of Structures we observed what seemed to be a particularly high incidence of diseased spadefish. Some specimens exhibited symptoms of fin rot, i.e. the membranes connecting dorsal and anal fin pterigiophores were severely eroded and the fin rays were often missing or reduced in length. Additionally, specimens having large lesions (particularly on the nape) were common. Some of the lesions were characterized with what appeared to be a fungal growth.

Following discussion of these findings with project management, we submitted a proposal to document our observations. We initially believed the phenomena was probably a result of seasonal stress as opposed to a BOF-specific condition, and suggested that in order to test this hypothesis, we would need to sample both in the BOF and at a control artificial reef, namely the V.A. Fogg Reef. The specific objectives of the effort were

1. To document by diver observation the relative incidence of diseased fish at (a) Production Platform "B", (b) the control satellite and (c) at the V.A. Fogg - Liberty Ship site (for a general comparison).
2. To collect ten diseased specimens from each of the three sites for a diagnosis of the pathogen (e.g., virus, bacteria, protozoan, etc.). Following the diagnosis, evaluations of the relationships among pathogen, host and hydrocarbon levels were to be made if possible based upon results of research performed by the BLM's OCS studies. Diseased specimens were to be analyzed by Dr. Don Lewis of Texas A&M College of Veterinary Medicine.
3. To collect four specimens (2 from Platform "B" and 2 from the V.A. Fogg) for independent bacterial analysis by Dr. Ronald Sizemore and hydrocarbon analysis by Dr. Brian Middleditch, both of the University of Houston.
4. To provide a written report of the results as soon as possible upon completion of the sample analyses. This report was to include evaluations of the significance of observations and make recommendations concerning the desirability of additional efforts in future research programs.

Performance of these objectives was estimated to require 13 man-days and two ship days using the *R/V Rachel Carson*.

The proposed study was officially awarded on 21 April 1978 in the form of a contract modification of Work Unit 2.3.8. The following represents the report of our findings and will be included as an appendix in our annual report for Work Unit 2.3.8.

CRUISE REPORT AND METHODS

A 3-man crew was on stand-by in Galveston on 20 April 1978 and departed to the BOF and V.A. Fogg reef in the *R/V Rachel Carson* on 21 April 1978. A census was made at each of the designated structures with 12 specimens collected at Production Platform 296B and 10 from Satellite Jacket 288-5 for pathogen analysis by Dr. Lewis. Two specimens were collected at the production platform for each of Drs. Sizemore and Middleditch. Outside the scope of the contract, five additional specimens were collected at each structure to provide tissues (gills, liver, intestine, kidney, skin) for future histopathological examination. Time-area counts of diseased spadefish were made by a dive team as described below and photographs were taken. Since the fathometer on the *R/V Rachel Carson* was inoperative, plans to proceed to the V.A. Fogg reef, a bottom structure presently unmarked by a buoy, were aborted.

Specimens for pathogen diagnosis were provided to Dr. Lewis in College Station, Texas within 12 hours of their collection. Tissues for histopathological examination were provided to Dr. Ray Bendele of the Texas Veterinary Medical Diagnostic Laboratory. Specimens designated for analysis by Dr. Sizemore and Dr. Middleditch were also transmitted.

Due to sea conditions, the next attempt to sample the V.A. Fogg reef was not made until 15 May 1978. On that date, the LORAN navigational system of the *R/V Rachel Carson* failed shortly upon arrival in the general vicinity of the Fogg reef. A search for the reef was made using the fathometer. The reef was not located and sampling was thus aborted. Neither a captain nor a vessel was available by 23 May 1978, and water temperatures had warmed such that we believed that even if the samples were obtained, any comparisons to the April samples would be invalid. Sampling attempts for this study were thus ended.

Visibility conditions in the water were relatively good on April 21. To determine the incidence of disease, the divers visually censused spadefish which were travelling in groups of 4 to 20 individuals. For the census, each of two divers examined a variable number of spadefish groups, recording both the total number of fish in the group and the number appearing diseased; i.e., with lesions and/or fin abnormalities. One of the divers (Diver I) only included advanced cases of fin decay and lesions in his classification of "diseased" whereas the other (Diver II) considered the fish diseased if any evidence of fin decay seemed apparent or if there were any lesions, abrasions or other abnormalities. Estimates by Diver I are thus representative for badly diseased specimens, whereas the estimates of the ratio of diseased fish to total number of fish counted by Diver II are more inclusive. Diver II required longer to make his determinations than Diver I and consequently counted fewer groups of fish and individuals within groups.

RESULTS AND DISCUSSION

The results of the survey expressed as the ratio of the number of diseased to total number of fish counted in a group are presented below.

Replicate Counts	Production Platform 296-B		Satellite 288-5	
	Diver I	Diver II	Diver I	Diver II
1	0.70	0.90	0.30	0.92
2	0.50	0.80	0.50	0.69
3	0.50	0.90	0.30	1.00
4	0.50	0.70	0.11	0.63
5	0.70		0.20	
6	0.80		0.24	
7	0.60		0.10	
$\bar{x}$	0.61	0.82	0.25	0.81

Badly diseased fish were more in evidence at the production platform than at the satellite, but close examination (Diver II) showed that about 80% of the populations at each structure exhibited at least minor evidence of physical damage.

Dr. Lewis reported that 7 of the 12 fish from the production platform possessed lesions of various types, 2 possessed symptoms of fin rot and 1 had a genetic abnormality in the region of the pectoral fin. Three of 7 fish with lesions were characterized by head or nape lesions. A marine fungus was recovered from 2 of the head lesions but was not identified by Dr. Lewis. Vibriosis was isolated from the 2 specimens from the production platform exhibiting symptoms of fin rot. Of the 10 specimens collected at the satellite jacket, 5 had head lesions, 1 had a lesion on the dorsal fin, 1 had a large traumatic lesion or "bite" and 1 possessed a tumor on the caudal fin. Vibriosis was not detected in any of these specimens, but 3 of the head lesions on fish from the satellite were characterized by the presence of the marine fungus mentioned above.

Results of the independent analysis performed by Dr. Sizemore corroborated the findings of Dr. Lewis. *Vibrio* was isolated by Sizemore from the lesions on the two fish he was provided from the production platform.

We believe the results to indicate that the winter season is a time of natural stress for BOF spadefish populations. Evidence from Work Unit 2.3.8 indicates that spadefish change food habits during winter; stress often accompanies changes in food habits. Potential pathogens are represented in the water column throughout the year, but are presumably not successful until the host is weakened. Some of the pathogens (e.g. the marine fungus) probably manifest themselves throughout the field under conditions of ambient stress whereas others (e.g. *Vibrio*) may not be able to attain success until the host is subjected to a greater level of stress than that resulting from normal seasonal changes.

In our other studies, we have demonstrated that spadefish are habitat faithful, i.e. they usually remain around a single structure. Further, we have predicted in our modeling of trophic relationships that spadefish around production platforms should be ingesting discharged hydrocarbons via particulates. Muscle tissue of spadefish collected from production platforms during 1977-1978 contained greater levels of hydrocarbons than muscle tissue of spadefish collected from satellite jackets (Brian Middleditch, personal communication).

Hydrocarbons are typically stored in lipid tissue. During winter, lipid metabolism becomes of greater importance to fish than it is during warmer seasons (Don Lewis, personal communication). The catabolism of these hydrocarbon-bearing tissues during winter may result in an additional stress factor allowing for the development of vibriosis in BOF spadefish living at production platforms.

CONCLUSIONS AND RECOMMENDATIONS

Our conclusions from the results of this preliminary and brief effort are given below. They sould be viewed as hypotheses which need to be tested.

1. Spadefish are subjected to seasonal stress which allows for increased development of disease epidemics throughout the BOF and probably other Gulf habitats.
2. The incidence of vibriosis was greater at the production platform than at a satellite jacket (none was observed at the satellite jacket).
3. Spadefish residing around production platforms may be subjected to a greater level of stress than those living around structures without discharges.
4. Hydrocarbons were implicated to be a potential factor producing the elevated stress levels.

We recommend that the above hypothesis concerning the role of hydrocarbons in producing vibriosis in spadefish be tested in future research programs. Results of our field studies to be performed during 1978-1979 should provide the data necessary to verify and expand this year's field observations. We believe that laboratory studies should be performed that would test the hypothesized hydrocarbon-vibriosis relationship. We suggest that Dr. Don Lewis of Texas A&M University be contacted as a potential sole-source contractor for a pilot study along these lines.

APPENDIX II.

TABLES

Table 1. Shell, mat and total biomass (kg/m^2) from template samples, summer 1977 and winter 1978.

			Summer			Winter		
Structure	Leg	Depth	Total	Shell	Mat	Total	Shell	Mat
Production 288A	East	S*	19.9	17.4	2.5			
		M	5.4	4.1	1.2			
		B	1.4	0.3	1.1			
	West	S	6.1	5.5	0.6			
		M	5.3	4.6	0.7			
		B	0.9	0.1	0.8			
Quarters 288A	East	S	13.2	12.0	1.1			
		M	9.7	8.3	1.3			
		B	2.2	1.3	0.9			
	West	S	16.2	14.4	1.8			
		M	19.1	15.8	3.1			
		B	2.3	1.3	1.0			
Production 296B	East	S				21.6	17.1	4.5
		M				20.9	13.4	7.5
		B				0.3	0.0	0.3
	West	S				9.6	7.5	2.1
		M				17.1	11.3	5.8
		B				1.4	0.6	0.8
Quarters 296B	East	S				38.2	29.5	8.7
		M				14.1	10.0	4.1
		B				3.1	1.6	1.5
	West	S				26.8	19.6	7.2
		M				9.9	7.0	2.9
		B				1.3	0.1	1.2
Satellite 288-5	East	S	11.6	9.5	2.1	17.7	13.0	4.7
		M	11.3	10.1	1.1	18.9	13.3	5.6
		B	1.7	0.3	1.4	2.6	1.9	0.7
	West	S	13.6	12.3	1.3	21.9	14.9	7.0
		M	9.1	7.7	1.4	27.3	14.6	12.7
		B	2.6	0.4	2.1	3.4	1.5	1.9

Table 2. Ratios of live to dead barnacles from template samples, summer 1977 and winter 1978.

SUMMER

Structure:	Production 288A		Quarters 288A		Satellite 288-5	
Leg:	East	West	East	West	East	West
Depth						
Surface	880:448	138:2,762	928:752	928:704	768:736	864:928
Midwater (8m)	144:16	160:112	1,136:112	1,120:272	688:448	496:400
Bottom (18m)	16:16	0:32	16:32	16:144	0:48	16:48

WINTER

Structure:	Production 296B		Quarters 296B		Satellite 288-5	
Leg:	East	West	East	West	East	West
Depth						
Surface	9,840:1,008	3,280:1,232	10,096:1,328	7,056:1,152	9,920:608	9,728:1,120
Midwater (8m)	2,032:240	960:96	2,864:720	2,608:400	336:1,520	2,592:1,216
Bottom (18m)	0:16	0:32	48:112	32:64	114:80	48:32

Table 3. Total weights and non-shell weights (g) from jar samples, summer 1977.

Sample Number: PLATFORM	LEG	DEPTH	TOTAL WEIGHT (g) 1	2	3	4	TOTAL	NONSHELL WEIGHT (g) 1	2	3	4	TOTAL
Production 288A	East	Surface (S)	1.2	5.3	2.6	1.7	10.8	1.0	1.1	2.1	1.5	5.7
		Midwater (M)	2.0	1.5	1.0	7.1	11.6	2.0	1.1	1.0	5.7	9.8
		Bottom (B)	1.4	2.0	2.3	2.2	7.9	1.4	2.0	2.3	2.2	7.9
	West	S	8.2	13.1	11.8	10.7	43.8	0.8	1.3	1.2	1.1	4.4
		M	0.9	1.4	0.3	0.5	3.1	0.8	0.7	0.3	0.3	2.1
		B	1.0	1.0	1.6	1.2	4.8	1.0	0.9	1.6	1.2	4.7
Quarters 288A	East	S	4.7	5.0	7.1	9.2	26.0	0.5	0.5	4.3	0.9	6.2
		M	3.4	0.3	2.1	1.7	7.5	3.4	0.3	1.1	1.0	5.9
		B	1.2	1.9	2.9	3.3	9.3	1.1	1.7	1.7	3.3	7.8
	West	S	7.9	6.9	4.1	6.3	25.2	2.4	2.1	2.9	1.9	9.3
		M	2.1	1.9	1.8	2.1	7.9	1.9	1.5	1.6	1.9	6.9
		B	7.9	7.2	2.1	4.5	21.7	5.5	6.5	2.1	4.5	18.6
Satellite	East	S	3.9	3.9	9.8	6.0	23.6	1.2	0.8	2.0	0.6	4.6
		M	2.0	1.0	1.0	1.0	5.0	1.2	0.9	0.9	0.1	3.1
		B	3.7	1.4	1.3	1.6	8.0	2.2	1.4	1.3	1.6	6.5
	West	S	7.9	2.4	19.6	8.1	38.0	1.6	1.2	2.0	1.6	6.4
		M	3.6	2.0	0.8	3.8	10.2	3.6	2.0	0.8	3.8	10.2
		B	5.4	7.8	7.6	1.5	22.3	5.4	7.8	6.1	1.5	20.8

Table 4. Results of analysis of variance on non-shell weights from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	71	17.5771			
Platform	2	1.0084	0.5042	3.54*	0.0359
Side	1	0.8960	0.8960	6.29*	0.0152
Depth	2	3.6307	1.8154	12.75**	<0.0001
Platform X Side	2	2.5180	1.2590	8.87**	0.0005
Platform X Depth	4	0.5813	0.1453	1.02^{ns}	0.4051
Side X Depth	2	0.5152	0.2596	1.81^{ns}	0.1737
Platform X Side X Depth	4	0.7367	0.1842	1.29^{ns}	0.2843
Residual	54	7.6907	0.1424		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

** = significant at $\alpha = 0.05$.

Table 5. Results of analysis of variance on total weights from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	71	46.9383			
Platform	2	1.3527	0.6764	2.56^{ns}	0.0869
Side	1	2.5567	2.5567	9.66**	0.0030
Depth	2	0.5387	0.2693	1.02^{ns}	0.3681
Platform X Side	2	19.4852	9.7426	36.82**	<0.0001
Platform X Depth	4	0.9008	0.2252	0.85^{ns}	0.4992
Side X Depth	2	1.9509	0.9755	3.69*	0.0316
Platform X Side X Depth	4	5.8658	1.4665	5.54**	0.0008
Residual	54	14.2874	0.2646		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

** = significant at $\alpha = 0.01$.

Table 6. Percent cover of taxa comprising the fouling mat from jar samples, summer 1977.

			% Cover					
Structure	Leg	Depth	Hydroid	Encrusting Sponge	Encrusting Bryozoan	Stalked Bryozoan	Algae	Other
Production 288A	East	Surface (S)	5	80	1.25		13.75	
		Midwater (M)	3.75	67.5		13.75	12.5	
		Bottom (B)	15	85				
	West	S	5	60		5	30	
		M	5	32.5	3.75	36.25	22.5	
		B	15	85				
Quarters 288A	E	S	6.25	61.25			32.5	
		M	7.5	35	10	46.25	1.25	
		B	17.5	82.5				
	W	S	5	80			15	
		M	5	55	12.5	8.75	18.75	
		B	23.75	57.5		1.25		17.5
Satellite 288-5	E	S	2.5	60			37.5	
		M	11.25	42.5		5	41.25	
		B	40	55		1.25		3.75
	W	S	1.25	27.5			71.25	
		M	15	77.5		7.5		
		B	25	75				

Table 7. Total weights and non-shell weights (g) from jar samples, winter 1978.

Sample Number:			TOTAL WEIGHT (g)					NON-SHELL WEIGHT (g)				
PLATFORM	LEG	DEPTH	1	2	3	4	Total	1	2	3	4	Total
Production 296B	East	S	10.8	6.7	22.9	13.7	54.1	3.2	1.3	9.2	5.5	19.2
		M	3.4	2.7	6.0	6.3	18.4	3.2	2.7	5.7	6.0	17.6
		B	0.5	0.4	0.7	0.8	2.4	0.5	0.2	0.7	0.4	1.8
	West	S	12.6	21.4	12.1	9.1	55.2	7.6	8.6	4.8	2.7	23.7
		M	2.3	10.5	8.7	6.3	27.8	2.2	5.3	5.2	6.3	19.0
		B	1.5	1.2	1.4	2.7	6.8	1.5	1.1	1.1	2.4	6.1
Quarters 296B	East	S	10.3	20.8	15.6	23.3	70.0	1.0	6.2	3.1	2.3	12.6
		M	13.8	10.7	5.2	4.6	34.3	10.4	5.4	4.7	4.1	24.6
		B	2.1	2.6	2.3	4.9	11.9	2.0	2.6	2.3	2.5	9.4
	West	S	18.9	13.1	21.7	20.6	74.3	3.8	2.6	6.5	2.1	15.0
		M	4.3	3.5	3.9	5.5	17.2	4.1	3.3	3.9	4.1	15.4
		B	1.7	1.0	2.3	1.5	6.5	1.4	0.9	2.1	1.2	5.6
Satellite 288-5	East	S	21.6	23.5	21.5	21.1	87.7	2.2	4.7	2.2	0.9	10.0
		M	10.7	18.5	12.1	3.3	44.6	4.3	5.6	6.1	3.3	19.3
		B	1.3	0.9	1.2	1.2	4.6	1.3	0.9	1.2	1.2	4.6
	West	S	15.0	21.4	23.3	24.4	84.1	1.5	6.4	4.7	7.3	19.9
		M	16.9	19.5	34.1	16.1	86.6	11.8	11.7	20.5	14.5	58.5
		B	6.3	2.3	3.2	1.8	13.6	6.3	2.3	3.2	1.8	13.6

Table 8. Results of analysis of variance on non-shell weights from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	71	42.9861			
Platform	2	1.6195	0.8097	3.90*	0.0261
Side	1	2.3832	2.3832	11.49**	0.0013
Depth	2	4.3652	2.1826	10.52**	<0.0001
Platform X Side	2	17.2776	8.6388	41.66**	<0.0001
Platform X Depth	4	4.2033	1.0508	5.07**	0.0015
Side X Depth	2	0.0318	0.0159	0.08^{ns}	0.9263
Platform X Side X Depth	4	1.9065	0.4766	2.30^{ns}	0.0707
Residual	54	11.1990	0.2074		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

** = significant at $\alpha = 0.01$.

Table 9. Results of analysis of variance on total weights from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	71	140.0361			
Platform	2	11.9463	5.9731	18.01**	<0.0001
Side	1	0.8467	0.8467	2.55^{ns}	0.1159
Depth	2	3.2540	1.6270	4.91*	0.0110
Platform X Side	2	97.4618	48.7309	146.97**	<0.0001
Platform X Depth	4	5.2562	1.3141	3.96**	0.0068
Side X Depth	2	0.3032	0.1516	0.46^{ns}	0.6355
Platform X Side X Depth	4	3.0632	0.7658	2.31^{ns}	0.0695
Residual	54	17.9049	0.3316		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$

** = significant at $\alpha = 0.05$.

Table 10. Results of analysis of variance on non-shell weights from jar samples at satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Square	Mean Squares	F	Pf>F
Total	47	35.2652			
Season	1	6.3778	6.3778	33.89**	<0.0001
Side	1	7.7844	7.7844	41.37**	<0.0001
Depth	2	3.2578	1.6289	8.66**	0.0009
Season X Side	1	0.4101	0.4101	2.18^{ns}	0.1486
Season X Depth	2	8.9355	4.4678	23.74**	<0.0001
Side X Depth	2	1.0940	0.5470	2.91^{ns}	0.0676
Season X Side X Depth	2	0.6312	0.3156	1.68^{ns}	0.2012
Residual	36	6.7745	0.1882		

ns = not significant at α = 0.05.

** = significant at α = 0.05.

Table 11. Results of analysis of variance on total weights from jar samples at satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	47	97.4730			
Season	1	23.1460	23.1460	56.15**	<0.0001
Side	1	4.9151	4.9151	11.92**	0.0014
Depth	2	32.2180	16.1090	39.08**	<0.0001
Season X Side	1	0.0052	0.0052	0.01^{ns}	0.9115
Season X Depth	2	19.8621	9.9311	24.09**	<0.0001
Side X Depth	2	1.1525	0.5762	1.40^{ns}	0.2602
Season X Side X Depth	2	1.3254	0.6627	1.61^{ns}	0.2144
Residual	36	14.8387	0.4122		

ns = not significant at $\alpha = 0.05$.

** = significant at $\alpha = 0.05$.

Table 12. Percent cover of taxa comprising the fouling mat from jar samples, winter 1978.

Structure	Leg	Depth	% Cover					
			Hydroid	Encrusting Sponge	Encrusting Bryozoan	Stalked Bryozoan	Algae	Other
Production 296B	East	Surface (S)	52.5	5			41.25	1.25
		Midwater (M)	28.75	67.5		3.75		
		Bottom (B)	42.5	42.5				15
	West	S	12.5				65	
		M	10	80		10		
		B	42.5	57.5				
Quarters 296B	E	S	45	6.25			16.25	32.5
		M	35	57.5		2.5	5	
		B	50	42.5	2.5			5
	W	S	27.5	12.5			55	5
		M	6.25	85		6.25	2.5	
		B	30	61.25				8.75
Satellite 288-5	E	S	17.5	3.75	1.25		45	32.5
		M	2.5	17.5		77.5		2.5
		B	11.25	83.75	2.5			2.5
	W	S	7.5	5			75	12.5
		M	1.25	3.75		95		
		B	3.75	93.75				2.5

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Table 13. Number of individuals of cryptic species from jar samples from production platform 288A, summer 1977.

Platform:	288A PRODUCTION								
Leg:	EAST				WEST				
Depth:	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Scypha sp.		2		2		1		1	3
Leuconia sp.		1		1					1
Cnidaria									
Anemone I									
Anemone II									
Medusa					1			1	1
Nemertea	2	2		4					4
Nematoda	26	26	8	60	66	26	8	100	160
Polychaeta									
Dodecaceria diceria		1		1					1
Dodecaceria sp.									
Lumbrineris coccinea									
Neanthes succinea		1		1					1
Sabellaria vulgaris beaufortensis									
Potamilla sp. I									
Potamilla sp. II									
Eupomatus dianthus									
E. protulicola									
Polydora ciliata									
P. colonia			7	7			4	4	11
Autolytus sp. I		3		3	1	3		4	7
Autolytus sp. II	6	3	1	10					10
Exogone dispar									
Haplosyllis spongicola	12	11	107	130		10	85	95	225
Odontosyllis enopla		1		1		3		3	4
Syllis cornuta									
Synsyllis longigularis	28	26	2	56	8	6		14	70
Trypanosyllis gemmipara		1		1					1
Syllid epitoke									
?*Polycirrus* sp.									
Polychaete larva					17			17	17
Unidentified polychaete									
Pycnogonida					2			2	2
Crustacea									
Tanais sp.	14	7		21	6			6	27
Colomastix halichondriae									
Corophium sp.	1			1			1	1	2
Erichthonius brasiliensis									
Elasmopus pectinicrus	1			1					1
Leucothoe spinicarpa									
Stenothoe gallensis									
Synalpheus fritzmuelleri		2		2		1		1	3
Periclimenes longicaudatus							1	1	1
Hexapanopeus paulensis									
Menippe mercenaria					1			1	1
Pilumnus sp.									
Pseudomedaeus agassizi									
Pelecypoda									
Isognomon bicolor	1			1					1
Ostrea equestris		1		1					1
Chama macerophylla									
Lithophaga bisculata		2		2					2
Musculus lateralis									
Anadara transversa									
Unidentified pelecypod									
Ophiuroidea									
Ophiactis savignyi		6		6		2		2	8
Total	91	96	125	312	102	52	99	253	565
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Number/m^2	12,639	13,333	17,361	14,182	14,167	7,222	13,750	11,500	13,140
Number of taxa	9	17	5	21	8	8	5	16	26
Species diversity (H")	1.69	2.14	0.57	1.81	1.16	1.52	0.56	1.56	1.79
Evenness (J)	0.77	0.76	0.36	0.59	0.56	0.73	0.35	0.56	0.55
Species richness (D)	1.77	3.51	0.83	3.48	1.51	1.77	0.87	2.71	3.95

Table 14. Number of individuals of cryptic species from jar samples from quarters platform 288A, summer 1977.

Platform:	288A QUARTERS								
Leg:	EAST				WEST				
Depth:	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Scypha sp.		2		2		13		13	15
Leuconia sp.									
Cnidaria									
Anemone I							1	1	1
Anemone II									
Medusa									
Nemertea					1			1	1
Nematoda	30	28	6	64	45	6	35	86	150
Polychaeta									
Dodecaceria diceria			2	2			2	2	4
Dodecaceria sp.							1	1	1
Lumbrineris coccinea							4	4	4
Neanthes succinea		1	1	2		1		1	3
Sabellaria vulgaris beaufortensis			1	1					1
Potamilla sp. I			2	2			30	30	32
Potamilla sp. II									
Euponatus dianthus							1	1	1
E. protulicola		1		1					1
Polydora ciliata							2	2	2
P. colonia		7		7		1		1	8
Autolytus sp. I		2		2		1		1	3
Autolytus sp. II	3			3	14	1	1	16	19
Exogone dispar									
Haplosyllis spongicola	42	77	108	227	72	70	25	167	394
Odontosyllis enopla		5		5					5
Syllis cornuta							2	2	2
Synsyllis longigularis	19	7	6	32	60	27	30	117	149
Trypanosyllis gemmipara	1	2		3	2	3	3	8	11
Syllid epitoke					1			1	1
?*Polycirrus* sp.		1		1					1
Polychaete larva									
Unidentified polychaete									
Pycnogonida									
Crustacea									
Tanais sp.	10			10	26	9		35	45
Colomastix halichondriae							3	3	3
Corophium sp.			1	1			16	16	17
Erichthonius brasiliensis		1		1		5		5	6
Elasmopus pectinicrus	1			1	3	1	2	6	7
Leucothoe spinicarpa		1		1					1
Stenothoe gallensis							3	3	3
Synalpheus fritzmuelleri	1			1			3	3	4
Periclimenes longicaudatus									
Hexapanopeus paulensis						1		1	1
Menippe mercenaria	1			1					1
Pilumnus sp.							1	1	1
Pseudomedaeus agassizi							1	1	1
Pelecypoda									
Isognomon bicolor		1		1					1
Ostrea equestris									
Chama macerophylla		1		1	2			2	3
Lithophaga bisculata		1		1		2		2	3
Musculus lateralis						2		2	2
Anadara transversa			1	1					1
Unidentified pelecypod									
Ophiuroidea									
Ophiactis savignyi	10	3		13		3		3	16
Total	118	141	128	387	226	146	166	538	925
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Number/m^2	16,389	19,583	17,777	17,591	31,389	20,278	23,056	24,455	21,512
Number of taxa	10	17	9	27	10	16	20	33	41
Species diversity (H")	1.68	1.61	0.71	1.57	1.65	1.78	2.23	2.19	2.03
Evenness (J)	0.73	0.57	0.32	0.47	0.72	0.64	0.75	0.63	0.55
Species richness (D)	1.89	3.23	1.65	4.36	1.66	3.01	3.72	5.09	5.86

Table 15. Number of individuals of cryptic species from jar samples from satellite jacket 288-5, summer 1977.

Platform:	SATELLITE 288-5								
Leg:	EAST				WEST				
Depth:	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Scypha sp.					1	4		5	5
Leuconia sp.					1			1	1
Cnidaria									
Anemone I									
Anemone II			9	9			6	6	15
Medusa									
Nemertea	5	1	3	9	4	1		5	14
Nematoda	47	23	17	87	75	23	25	123	210
Polychaeta									
Dodecaceria dioeria			1	1			1	1	2
Dodecaceria sp.									
Lumbrineris coccinea									
Neanthes succinea			4	4	3		1	4	8
Sabellaria vulgaris beaufortensis									
Potamilla sp. I									
Potamilla sp. II							1	1	1
Eupomatus dianthus							2	2	2
E. protulicola		1		1		1		1	2
Polydora ciliata			5	5					5
P. colonia			1	1			40	40	41
Autolytus sp. I			1	1					1
Autolytus sp. II	8	2	3	13	1	1		2	15
Exogone dispar	1			1	7			7	8
Haplosyllis spongicola	2	12	51	65	19	10	118	147	212
Odontosyllis enopla			3	3		1		1	4
Syllis cornuta									
Synsyllis longigularis	34	16	28	78	58	25	20	103	181
Trypanosyllis gemmipara	9		5	14	16	2	1	19	33
Syllid epitoke									
?*Polycirrus* sp.		1	1	2					2
Polychaete larva									
Unidentified polychaete			16	16					16
Pycnogonida					1			1	1
Crustacea									
Tanais sp.	55	1		56	38	1		39	95
Colomastix halichondriae		1		1			2	2	3
Corophium sp.			5	5			3	3	8
Erichthonius brasiliensis	1		1	2	1			1	3
Elasmopus pectinicrus					17		2	19	19
Leucothoe spinicarpa	1		7	8		5	6	11	19
Stenothoe gallensis			1	1					1
Synalpheus fritzmuelleri		1		1	1			1	2
Periclimenes longicaudatus									
Hexapanopeus paulensis									
Menippe mercenaria									
Pilumnus sp.									
Pseudomedaeus agassizi									
Pelecypoda									
Isognomon bicolor	1			1					1
Ostrea equestris									
Chama macerophylla									
Lithophaga bisculata	2			2	2			2	4
Musculus lateralis					1			1	1
Anadara transversa					1			1	1
Unidentified pelecypod									
Ophiuroidea									
Ophiactis savignyi	6	1		7	24	2		26	33
Total	172	60	162	394	271	76	228	575	969
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Number/m^2	23,889	8,333	22,500	17,909	37,639	10,556	31,667	26,136	22,535
Number of taxa	13	11	19	27	19	12	14	30	35
Species diversity (H")	1.78	1.63	2.25	2.32	2.11	1.80	1.57	2.23	2.36
Evenness (J)	0.69	0.68	0.76	0.71	0.72	0.73	0.60	0.66	0.66
Species richness (D)	2.33	2.44	3.54	4.35	3.21	2.54	2.39	4.56	4.94

Table 16. Wet weights (g) of cryptic species from jar samples from production platform 288A, summer 1977.

Platform:	288A PRODUCTION								
Leg:	EAST				WEST				
Depth:	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Scypha sp.		1.0		1.0		0.8		0.8	1.8
Leuconia sp.		2.5		2.5					2.5
Cnidaria									
Anemone I									
Anemone II									
Medusa					1.3			1.3	1.3
Nemertea	0.2	0.9		1.1					1.1
Nematoda	0.9	1.2	0.4	2.5	1.6	0.9	1.5	4.0	6.5
Polychaeta									
Dodecaceria diceria		0.1		0.1					0.1
Dodecaceria sp.									
Lumbrineris coccinea									
Neanthes succinea		0.9		0.9					0.9
Sabellaria vulgaris beaufortensis									
Potamilla sp. I									
Potamilla sp. II									
Eupomatus dianthus									
E. protulicola									
Polydora ciliata									
P. colonia			0.5	0.5			0.6	0.6	1.1
Autolytus sp. I		0.1		0.1	0.1	0.2		0.3	0.4
Autolytus sp. II	1.1	0.4	0.1	1.6					1.6
Exogone dispar									
Haplosyllis spongicola	1.0	0.7	20.8	22.5		0.6	10.3	10.9	33.4
Odontosyllis enopla		0.1		0.1		0.2		0.2	0.3
Syllis cornuta									
Synsyllis longigularis	26.0	19.1	0.7	45.8	1.3	0.8		2.1	47.9
Trypanosyllis gemmipara		0.3		0.3					0.3
Syllid epitoke									
?*Polycirrus* sp.									
Polychaete larva					0.5			0.5	0.5
Unidentified polychaete									
Pycnogonida					1.1			1.1	1.1
Crustacea									
Tanais sp.	2.5	2.0		4.5	2.7			2.7	7.2
Colomastix halichondriae									
Corophium sp.	0.2			0.2			1.8	1.8	2.0
Erichthonius brasiliensis									
Elasmopus pectinicrus	0.1			0.1					0.1
Leucothoe spinicarpa									
Stenothoe gallensis									
Synalpheus fritzmuelleri		12.7		12.7		8.4		8.4	21.1
Periclimenes longicaudatus							10.8	10.8	10.8
Hexapanopeus paulensis									
Menippe mercenaria					56.3			56.3	56.3
Pilumnus sp.									
Pseudomedaeus agassizi									
Pelecypoda									
Isognomon bicolor	0.6			0.6					0.6
Ostrea equestris		36.7		36.7					36.7
Chama macerophylla									
Lithophaga bisulcata		1.1		1.1					1.1
Musculus lateralis									
Anadara transversa									
Unidentified pelecypod									
Ophiuroidea									
Ophiactis savignyi		30.0		30.0		4.6		4.6	34.6
Total	32.6	109.8	22.5	164.9	64.9	16.5	25.0	106.4	271.3
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Wet weight/m^2	4,528	15,250	3,125	7,495	9,014	2,292	3,472	4,836	6,309
Number of taxa	9	17	5	21	8	8	5	16	26
Species diversity (H")	0.85	1.74	0.36	1.94	0.62	1.38	1.	1.	2.27
Evenness (J)	0.39	0.61	0.22	0.64	0.30	0.66	0.73	0.62	0.70
Species richness (D)	2.30	3.41	1.28	3.92	1.68	2.50	1.	3.21	4.46

Table 17. **Wet weight (g) of cryptic species from jar samples from quarters platform 288A, summer 1977.**

Platform:	288A QUARTERS								
Leg:	EAST				WEST				
Depth:	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Scypha sp.		0.5		0.5		20.7		20.7	21.2
Leuconia sp.									
Cnidaria									
Anemone I							3.9	3.9	3.9
Anemone II									
Medusa									
Nemertea					0.1			0.1	0.1
Nematoda	0.6	0.5	0.3	1.4	2.1	0.3	0.6	3.0	4.4
Polychaeta									
Dodecaceria diceria			0.6	0.6			0.6	0.6	1.2
Dodecaceria sp.							1.5	1.5	1.5
Lumbrineris coccinea							66.9	66.9	66.9
Neanthes succinea		2.0	0.2	2.2		2.3		2.3	4.5
Sabellaria vulgaris beaufortensis			0.4	0.4					0.4
Potamilla sp. I			0.2	0.2			17.9	17.9	18.1
Potamilla sp. II									
Eupomatus dianthus							12.4	12.4	12.4
E. protulicola		0.6		0.6					0.6
Polydora ciliata							5.2	5.2	5.2
P. colonia		0.7		0.7		0.1		0.1	0.8
Autolytus sp. I		0.3		0.3		0.1		0.1	0.4
Autolytus sp. II	0.3			0.3	2.1	0.1	0.1	2.3	2.6
Exogone dispar									
Haplosyllis spongicola	7.7	12.4	15.8	35.9	9.3	15.4	6.2	30.9	66.8
Odontosyllis enopla		0.9		0.9					0.9
Syllis cornuta							0.4	0.4	0.4
Synsyllis longigularis	3.8	1.2	2.3	7.3	28.7	21.9	12.2	62.8	70.1
Trypanosyllis gemmipara	0.1	5.1		5.2	1.4	1.7	2.8	5.9	11.1
Syllid epitoke					0.1			0.1	0.1
?*Polycirrus* sp.		0.5		0.5					0.5
Polychaete larva									
Unidentified polychaete									
Pycnogonida									
Crustacea									
Tanais sp.	1.4			1.4	5.8	1.8		7.6	9.0
Colomastix halichondriae							0.3	0.3	0.3
Corophium sp.			0.1	0.1			1.8	1.8	1.9
Erichthonius brasiliensis		0.3		0.3		1.8		1.8	2.1
Elasmopus pectinicrus	0.1			0.1	10.6	0.2	0.3	11.1	11.2
Leucothoe spinicarpa		0.4		0.4					0.4
Stenothoe gallensis							1.5	1.5	1.5
Synalpheus fritzmuelleri	8.3			8.3			35.3	35.3	43.6
Periclimenes longicaudatus									
Hexapanopeus paulensis						4.6		4.6	4.6
Menippe mercenaria	39.7			39.7					39.7
Pilumnus sp.							3.7	3.7	3.7
Pseudomedaeus agassizi							119.0	119.0	119.0
Pelecypoda									
Isognomon bicolor		53.5		53.5					53.5
Ostrea equestris									
Chama macerophylla		1.5		1.5	54.3			54.3	55.8
Lithophaga bisculata		1.1		1.1		2.2		2.2	3.3
Musculus lateralis						3.6		3.6	3.6
Anadara transversa			0.9	0.9					0.9
Unidentified pelecypod									
Ophiuroidea									
Ophiactis savignyi	70.2	29.0		99.2		9.9		9.9	109.1
Total	132.2	110.5	20.8	263.5	114.5	86.7	292.6	493.8	757.3
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Wet weight/m^2	18,361	15,347	2,889	11,977	15,903	12,042	40,639	22,445	17,612
Number of taxa	10	17	9	27	10	16	20	33	41
Species diversity (H")	1.24	1.54	0.94	1.84	1.49	2.02	1.84	2.52	2.72
Evenness (J)	0.54	0.54	0.43	0.56	0.65	0.73	0.62	0.72	0.73
Species richness (D)	1.84	3.40	2.64	4.66	1.90	3.36	3.35	5.16	6.03

Table 18. Wet weight (g) of cryptic species from jar samples from satellite jacket 288-5, summer 1977.

Platform:	SATELLITE 288-5								
Leg:	EAST				WEST				
Depth:	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Scypha sp.					0.9	1.2		2.1	2.1
Leuconia sp.					0.4			0.4	0.4
Cnidaria									
Anemone I									
Anemone II			9.7	9.7			7.7	7.7	17.4
Medusa									
Nemertea	0.6	0.2	0.2	1.0	0.6	0.1		0.7	1.7
Nematoda	1.1	0.4	0.4	1.9	0.8	0.4	0.5	1.7	3.6
Polychaeta									
Dodecaceria diceria			0.2	0.2			0.2	0.2	0.4
Dodecaceria sp.									
Lumbrineris coccinea									
Neanthes succinea			3.0	3.0	16.2		6.4	22.6	25.6
Sabellaria vulgaris beaufortensis									
Potamilla sp. I									
Potamilla sp. II							3.2	3.2	3.2
Eupomatus dianthus							2.7	2.7	2.7
E. protulicola		2.3		2.3		0.8		0.8	3.1
Polydora ciliata			7.0	7.0					7.0
P. colonia			0.3	0.3			14.2	14.2	14.5
Autolytus sp. I			0.3	0.3					0.3
Autolytus sp. II	1.3	0.4	0.3	2.0	0.1	0.1		0.2	2.2
Exogone dispar	0.1			0.1	0.3			0.3	0.4
Haplosyllis spongicola	0.6	1.2	14.3	16.1	3.0	0.9	38.9	42.8	58.9
Odontosyllis enopla			0.4	0.4		0.3		0.3	0.7
Syllis cornuta									
Synsyllis longigularis	5.5	1.6	4.3	11.4	10.7	6.2	4.7	21.6	33.0
Trypanosyllis gemmipara	15.4		1.6	17.0	56.2	1.4	1.4	59.0	76.0
Syllid epitoke									
?*Polycirrus* sp.		0.5	16.2	16.7					16.7
Polychaete larva									
Unidentified polychaete			3.8	3.8					3.8
Pycnogonida					0.4			0.4	0.4
Crustacea									
Tanais sp.	5.9	0.2		6.1	5.2	0.2		5.4	11.5
Colomastix halichondriae		0.1		0.1			0.3	0.3	0.4
Corophium sp.			0.9	0.9			0.8	0.8	1.7
Erichthonius brasiliensis	0.2		0.3	0.5	0.2			0.2	0.7
Elasmopus pectenicrus					10.9		0.3	11.2	11.2
Leucothoe spinicarpa	0.3		1.7	2.0		1.9	3.3	5.2	7.2
Stenothoe gallensis			0.1	0.1					0.1
Synalpheus fritzmuelleri		6.3		6.3	17.5			17.5	23.8
Periclimenes longicaudatus									
Hexapanopeus paulensis									
Menippe mercenaria									
Pilumnus sp.									
Pseudomedaeus agassizi									
Pelecypoda									
Isognomon bicolor	0.6			0.6					0.6
Ostrea equestris									
Chama macerophylla									
Lithophaga bisulcata	12.2			12.2	1.6			1.6	13.8
Musculus lateralis					0.7			0.7	0.7
Anadara transversa					49.8			49.8	49.8
Unidentified pelecypod									
Ophiuroidea									
Ophiactis savignyi	19.3	1.2		20.5	131.4	6.3		137.7	158.2
Total	63.1	14.4	65.0	142.5	306.9	19.8	84.6	411.3	553.8
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Wet weight/m^2	8,764	2,000	9,028	6,477	42,626	2,750	11,750	18,695	12,879
Number of taxa	13	11	19	27	19	12	14	30	35
Species diversity (H")	1.80	1.78	2.14	2.64	1.76	1.82	1.79	2.21	2.50
Evenness (J)	0.70	0.74	0.73	0.80	0.60	0.73	0.68	0.65	0.70
Species richness (D)	2.90	3.75	4.31	5.24	3.14	3.68	2.93	4.82	5.38

Table 19. Results of analysis of variance on species diversity (H''_n) based on numbers of individuals of cryptic species from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	4.6222			
Platform	2	1.0289	0.5145	2.09^{ns}	0.2387
Side	1	0.0057	0.0057	0.02^{ns}	0.8864
Depth	2	0.6460	0.3230	1.31^{ns}	0.3641
Platform X Side	2	0.6832	0.3416	1.39^{ns}	0.3480
Platform X Depth	4	1.1443	0.5722	1.16^{ns}	0.4432
Side X Depth	2	0.1310	0.0655	0.27^{ns}	0.7786
Residual	4	0.9830	0.2457		

ns = not significant at α = 0.05.

Table 20. Results of analysis of variance on evenness (J_n) based on numbers of individuals of cryptic species from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	0.3764			
Platform	2	0.0369	0.0185	1.17^{ns}	0.3987
Side	1	0.0014	0.0014	0.09^{ns}	0.7793
Depth	2	0.1139	0.0569	3.60^{ns}	0.1276
Platform X Side	2	0.0501	0.0250	1.58^{ns}	0.3117
Platform X Depth	4	0.0936	0.0234	1.48^{ns}	0.3568
Side X Depth	2	0.0172	0.0086	0.54^{ns}	0.6181
Residual	4	0.0633	0.0158		

ns = not significant at $\alpha = 0.05$.

Table 21. Results of analysis of variance on species richness (D_n) based on numbers of individuals of cryptic species from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	13.6810			
Platform	2	3.5550	1.7775	2.39^{ns}	0.2073
Side	1	0.0145	0.0145	0.02^{ns}	0.8958
Depth	2	1.6502	0.8251	1.11^{ns}	0.4134
Platform X Side	2	1.0680	0.5340	0.72^{ns}	0.5411
Platform X Depth	4	3.6809	0.9202	1.24^{ns}	0.4203
Side X Depth	2	0.7411	0.3706	0.50^{ns}	0.6406
Residual	4	2.9714	0.7428		

ns = not signficant at $\alpha = 0.05$.

Table 22. Results of analysis of variance on species diversity (H''_w) based on weight of cryptic species from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	4.2439			
Platform	2	2.0736	1.0382	10.94*	0.0239
Side	1	0.1267	0.1267	1.34^{ns}	0.3121
Depth	2	0.5951	0.0298	3.14^{ns}	0.1515
Platform X Side	2	0.3454	0.1727	1.82^{ns}	0.2739
Platform X Depth	4	0.5334	0.1334	1.41^{ns}	0.3745
Side X Depth	2	0.1905	0.0953	1.00^{ns}	0.4431
Residual	4	0.3792	0.0948		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

Table 23. Results of analysis of variance on evenness (J_w) based on weight of cryptic species from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	0.4226			
Platform	2	0.1345	0.0673	4.64^{ns}	0.0906
Side	1	0.0356	0.0356	2.45^{ns}	0.1923
Depth	2	0.0612	0.0306	2.11^{ns}	0.2365
Platform X Side	2	0.0455	0.0228	1.57^{ns}	0.3136
Platform X Depth	4	0.0430	0.0108	0.74^{ns}	0.6101
Side X Depth	2	0.0447	0.0224	1.54^{ns}	0.3185
Residual	4	0.0580	0.0145		

ns = not significant at $\alpha = 0.05$.

Table 24. Results of analysis of variance on species richness (D_w) based on weight of cryptic species from jar samples, summer 1977.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	13.5086			
Platform	2	5.7414	2.8707	10.83*	0.0243
Side	1	0.2335	0.2335	0.88^{ns}	0.4012
Depth	2	3.5043	1.7522	6.61^{ns}	0.0540
Platform X Side	2	0.5102	0.2551	0.96^{ns}	0.4559
Platform X Depth	4	2.4178	0.6044	2.28^{ns}	0.2222
Side X Depth	2	0.0410	0.0205	0.08^{ns}	0.9269
Residual	4	1.0605	0.2651		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

Table 25. Number of individuals of cryptic species from jar samples from production platform 296B, winter 1978.

Platform:	PRODUCTION 296B								
Leg :	EAST				WEST				
Depth :	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Heterocoel calcareous sponge	2			2		65		65	67
Nemertea	15		7	22	31		1	32	54
Platyhelminthes			1	1					1
Nematoda	20	7	36	63	39	2	12	53	116
Cnidaria									
Anemone sp. 2			26	26			12	12	38
Medusa									
Polychaeta									
Dodecaceria diceria							1	1	1
Ctenodrilus serratus	2			2	15			15	17
Neanthes succinea		2		2	1	1		2	4
Phyllodocidae			1	1			1	1	2
Harmothoe sp.									
Sabellaria vulgaris									
Potamilla sp. 1			17	17					17
Eupomatus dianthus		1		1					1
E. proticula									
Polydora ciliata		2	2	4		1		1	5
P. colonia		46		46		66	2	68	114
Spionid sp. 3									
Autolytus sp. 1					8	1		9	9
Autolytus sp. 2	13	4	6	23	14	8	8	30	53
Autolytus sp. 3									
Exogone dispar					9			9	9
Haplosyllis spongicola		16	7	23	2	52	9	63	86
Odontosyllis enopla			2	2	2			2	4
Synsyllis longigularis	25	21	4	50	15	36	18	69	119
Syllis cornuta	1			1	2			2	3
?*Streptosyllis* sp.					7			7	7
Trypanosyllis gemmipara		1	2	3		2	1	3	6
Syllid epitoke					3			3	3
Eupolymnia crassicornis									
?*Polycirrus* sp.			1	1					1
Oligochaeta									
Pycnogonida	4			4					4
Crustacea									
Tanais sp.	75	1		76	33			33	109
Dynamene sp.									
Caprella equilibra	255		42	297	1		24	25	322
Colomastix halichondriae							1	1	1
Corophium sp.			1	1			51	51	52
Erichthonius brasiliensis		3	8	11		6	4	10	21
Elasmopus pectinicrus	3			3					3
Jassa falcata	45	14	38	97	1	14	12	27	124
Leucothoe spinicarpa		1	1	2		10	4	14	16
Stenothoe gallensis	33	9	8	50			5	5	55
Synalpheus fritzmuelleri									
Hexapanopeus paulensis									
Pseudomedaeus agassizi									
Menippe mercenaria									
Gastropoda									
Doto sp.	30			30	28			28	58
Pelecypoda									
Anadara transversa							1	1	1
Arca imbricata			1	1					1
Chama macerophylla			1	1					1
Heterodonta						2		2	2
Isognomon bicolor					4			4	4
Lithophaga aristata									
L. bisulcata			5	5	2		2	4	9
Musculus lateralis					3		2	5	5
Pteria colymbus									
Ostrea equestris									
Echinodermata									
Holothuroidea			1	1					1
Ophiactis savignyi		1		1			1	1	2
Ophiothrix angulata									
Ascideacea									
Ascidean sp. 1			52	52			66	66	118
TOTAL	521	131	270	922	220	266	238	724	1646
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Number per m^2 (x 1000)	72	18	38	42	31	37	33	33	38
Number of taxa	13	16	24	35	20	14	22	36	45
Species diversity (H")	1.74	2.07	2.44	2.48	2.59	1.92	2.30	2.98	2.90
Evenness (J)	0.68	0.75	0.77	0.70	0.82	0.73	0.74	0.83	0.76
Species richness (D)	1.92	3.08	4.11	4.98	3.52	2.33	3.84	5.32	5.94

Table 26. Number of individuals of cryptic species from jar samples from quarters platform 296B, winter 1978.

Platform:	QUARTERS 296 B								
Leg :	EAST				WEST				
Depth :	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Heterocoel calcareous sponge							1	1	1
Nemertea	18	16		34	6			6	40
Platyhelminthes									
Nematoda	45	6	27	78	53		27	80	158
Cnidaria									
Anemone sp. 2		27	16	43		5	28	33	76
Medusa		1		1					1
Polychaeta									
Dodecaceria diceria									
Ctenodrilus serratus					19			19	19
Neanthes succinea	1	2	1	4	1		2	3	7
Phyllodocidae									
Harmothoe sp.									
Sabellaria vulgaris							1	1	1
Potamilla sp. 1			4	4					4
Euponatus dianthus			19	19					19
E. protulicola							1	1	1
Polydora ciliata			3	3		4	8	12	15
P. colonia		5	3	8		14		14	22
Spionid sp. 3			4	4					4
Autolytus sp. 1	6	1		7					7
Autolytus sp. 2	20	10	8	38	21	30	6	57	95
Autolytus sp. 3									
Exogone dispar		1		1		2	1	3	4
Haplosyllis spongicola		1	48	49			97	97	146
Odontosyllis enopla			1	1			1	1	2
Synsyllis longigularis	59	44	12	115	29	29	20	78	193
Syllis cornuta					3			3	3
?*Streptosyllis* sp.					1			1	1
Trypanosyllis gemmipara	1	7	5	13	3	7	1	11	24
Syllid epitoke	2			2			1	1	3
Eupolymnia crassicornis									
?*Polycirrus* sp.			3	3			2	2	5
Oligochaeta		1		1					1
Pycnogonida	2			2					2
Crustacea									
Tanais sp.	85	16		101	18			18	119
Dynamene sp.									
Caprella equilibra	222		12	234	28		20	48	282
Colomastix halichondriae			4	4			3	3	7
Corophium sp.			11	11			93	93	104
Erichthonius brasiliensis			1	1		3	1	4	5
Elasmopus pectinicrus	7			7	1			1	8
Jassa falcata	2031	14	5	2050	294	7	23	324	2374
Leucothoe spinicarpa		1	9	10			7	7	17
Stenothoe gallensis	721	11	19	751	68	12	3	83	834
Synalpheus fritzmuelleri		4		4					4
Hexapanopeus paulensis			2	2					2
Pseudomedaeus agassizi							1	1	1
Menippe mercenaria									
Gastropoda									
Doto sp.	8			8	2			2	10
Pelecypoda									
Anadara transversa			1	1			3	3	4
Arca imbricata									
Chama macerophylla		3	6	9					9
Heterodonta			1	1					1
Isognomon bicolor	1	1		2	6	1		7	9
Lithophaga aristata									
L. bisculata	1	3	3	7	3	2	11	16	23
Musculus lateralis		14		14	5	2	4	11	25
Pteria colymbus									
Ostrea equestris						1		1	1
Echinodermata									
Holothuroidea		1	1	2			1	1	3
Ophiactis savignyi			9	9					9
Ophiothrix angulata									
Ascideacea									
Ascidean sp. 1							30	30	30
TOTAL	3230	190	238	3658	561	119	397	1077	4735
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Number per m^2 (x 1000)	448	27	33	166	78	17	55	49	110
Number of taxa	17	23	28	41	18	14	28	38	50
Species diversity (H")	1.16	2.54	2.82	1.60	1.75	2.13	2.39	2.56	1.93
Evenness (J)	0.41	0.81	0.93	0.43	0.60	0.81	0.72	0.70	0.49
Species richness (D)	1.98	4.19	4.93	4.88	2.69	2.72	4.51	5.30	5.79

Table 27. Number of individuals of cryptic species from jar samples from satellite jacket 288-5, winter 1978.

Platform:	SATELLITE 288-5								
Leg :	EAST				WEST				
Depth :	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Heterocoel calcareous sponge	14	29		43	13	25		38	81
Nemertea							2	2	2
Platyhelminthes	37	8	26	71	252	12	5	269	340
Nematoda									
Cnidaria									
Anemone sp. 2	1	7	3	11		1	12	13	24
Medusa									
Polychaeta							2	2	2
Dodecaceria diceria	14			14	32			32	46
Ctenodrilus serratus	3	3		6	3	3	1	7	13
Neanthes succinea									
Phyllodocidae						1		1	1
Harmothoe sp.							2	2	2
Sabellaria vulgaris			11	11			30	30	41
Potamilla sp. 1									
Eupomatus dianthus									
E. protulicola		5	2	7			1	1	8
Polydora ciliata		37	52	89			96	96	185
P. colonia									
Spionid sp. 3									
Autolytus sp. 1	19	3	1	23	19	1		20	43
Autolytus sp. 2		2		2	1	1		2	4
Autolytus sp. 3					1			1	1
Exogone dispar		13	17	30		115	6	121	151
Haplosyllis spongicola						5		5	5
Odontosyllis enopla			3	3		10	11	21	24
Synsyllis longigularis	1			1	27			27	28
Syllis cornuta					2			2	2
?Streptosyllis sp.	1	10	1	12	5	2	5	12	24
Trypanosyllis gemmipara					1			1	1
Syllid epitoke		1		1					1
Eupolymnia crassicornis							2	2	2
?Polycirrus sp.									
Oligochaeta									
Pycnogonida									
Crustacea	28			28	7	1		8	36
Tanais sp.	4			4	1			1	5
Dynamene sp.	293	1032	30	1355	548	682		1230	2585
Caprella equilibra							1	1	1
Colomastix halichondriae		5	243	248			199	199	447
Corophium sp.		129	33	162		2244	16	2260	2422
Erichthonius brasiliensis	12			12	8	8		16	28
Elasmopus pectinicrus	1308	54	77	1439	472	505	40	1017	2456
Jassa falcata			1	1		21	3	24	25
Leucothoe spinicarpa		16	8	24	16	61	1	78	102
Stenothoe gallensis									
Synalpheus fritzmuelleri									
							2	2	2
Hexapanopeus paulensis						2		2	2
Pseudomedaeus agassizi						1		1	1
Menippe mercenaria									
Gastropoda	12			12	11			11	23
Doto sp.									
Pelecypoda									
Anadara transversa									
Arca imbricata		3		3		9		9	12
Chama macerophylla	1			1	1			1	2
Heterodonta	10	1		11	29	3		32	43
Isognomon bicolor						1		1	1
Lithophaga aristata	1	1		2	1		3	4	6
L. bisculata		3		3	6	4		10	13
Musculus lateralis	1	1		2					2
Pteria colymbus									
Ostrea equestris									
Echinodermata									
Holothuroidea	7	50		57	50	63	1	114	171
Ophiactis savignyi						1		1	1
Ophiothrix angulata									
Ascidiacea			13	13			2	2	15
Ascidean sp. 1									
TOTAL	1767	1413	521	3701	1506	3782	443	5731	9432
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Number per m^2 (x 1000)	245	196	72	168	209	525	62	261	219
Number of taxa	19	22	16	33	23	26	23	46	48
Species diversity (H")	0.96	1.17	1.82	1.69	1.70	1.30	1.84	1.90	1.94
Evenness (J)	0.33	0.38	0.66	0.48	0.54	0.40	0.59	0.50	0.50
Species richness (D)	2.41	2.90	2.40	3.89	3.01	3.03	3.61	5.20	5.14

Table 28. Wet weight (g) of cryptic species from jar samples from production platform 296B, winter 1978.

Platform:	PRODUCTION 296 B								
Leg :	EAST				WEST				
Depth :	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Heterocoel calcareous sponge		0.4		0.4		20.2		20.2	20.6
Nemertea	5.9		2.8	8.7	4.1		0.2	4.3	13.0
Platyhelminthes			1.4	1.4					1.4
Nematoda	0.4	0.4	0.6	1.4	0.8	0.2	0.4	1.4	2.8
Cnidaria									
Anemone sp. 2			40.9	40.9			18.0	18.0	58.9
Medusa									
Polychaeta									
Dodecaceria diceria							0.2	0.2	0.2
Ctenodrilus serratus	0.1			0.1	0.3			0.3	0.4
Neanthes succinea		12.1		12.1	131.7	13.4		145.1	157.2
Phyllodocidae			0.8	0.8			1.2	1.2	2.0
Harmothoe sp.									
Sabellaria vulgaris									
Potamilla sp. 1			3.5	3.5					3.5
Eupomatus dianthus		3.4		3.4					3.4
E. protulicola									
Polydora ciliata		1.3	1.7	3.0		0.1		0.1	3.1
P. colonia		13.3		13.3		16.1	1.1	17.2	30.5
Spionid sp. 3									
Autolytus sp. 1					1.3	0.6		1.9	1.9
Autolytus sp. 2	3.2	0.9	2.0	6.1	1.5	3.7	6.7	11.9	18.0
Autolytus sp. 3									
Exogone dispar					0.4			0.4	0.4
Haplosyllis spongicola		3.7	1.6	5.3	0.3	17.3	3.0	20.6	25.9
Odontosyllis enopla			0.4	0.4	0.6			0.6	1.0
Synsyllis longigularis	21.0	16.7	2.8	40.5	13.5	24.0	11.2	48.7	89.2
Syllis cornuta	0.1			0.1	1.1			1.1	1.2
?*Streptosyllis* sp.					0.5			0.5	0.5
Trypanosyllis gemmipara		3.9	2.3	6.2		4.8	0.7	5.5	11.7
Syllid epitoke					0.6			0.6	0.6
Eupolymnia crassicornis									
?*Polycirrus* sp.			5.5	5.5					5.5
Oligochaeta									
Pycnogonida	1.5			1.5					1.5
Crustacea									
Tanais sp.	16.3	0.1		16.4	8.9			8.9	25.3
Dynamene sp.									
Caprella equilibra	712.7		15.7	728.4	1.4		10.1	11.5	739.9
Colomastix halichondriae							0.2	0.2	0.2
Corophium sp.			0.3	0.3			22.8	22.8	23.1
Erichthonius brasiliensis		4.5	2.8	7.3		5.7	1.1	6.8	14.1
Elasmopus pectinicrus	1.1			1.1					1.1
Jassa falcata	14.2	7.2	29.5	50.9	0.3	11.2	10.8	22.3	73.2
Leucothoe spinicarpa		2.9	0.2	3.1		7.6	2.4	10.0	13.1
Stenothoe gallensis	3.3	4.1	2.0	9.4			0.8	0.8	10.2
Synalpheus fritzmuelleri									
Hexapanopeus paulensis									
Pseudomedaeus agassizi									
Menippe mercenaria									
Gastropoda									
Doto sp.	30.2			30.2	18.3			18.3	48.5
Pelecypoda									
Anadara transversa							2.0	2.0	2.0
Arca imbricata			0.1	0.1					0.1
Chama macerophylla			4.2	4.2					4.2
Heterodonta						7.9		7.9	7.9
Isognomon bicolor					2.7			2.7	2.7
Lithophaga aristata									
L. bisulcata			36.1	36.1	3.2		0.7	3.9	40.0
Musculus lateralis					19.8		13.7	33.5	33.5
Pteria colymbus									
Ostrea equestris									
Echinodermata									
Holothuroidea			0.4	0.4			0.5	0.5	0.9
Ophiactis savignyi		1.7		1.7					1.7
Ophiothrix angulata									
Ascideacea									
Ascidean sp. 1			44.1	44.1			66.5	66.5	110.6
TOTAL	810.0	76.6	201.7	1088.3	211.3	132.8	174.3	518.4	1606.7
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Wet weight (g)/m^2	113	11	28	49	29	18	24	24	37
Number of taxa	13	16	24	35	20	14	22	36	45
Species diversity (H")	0.59	2.30	2.21	1.54	1.47	2.28	2.11	2.63	2.23
Evenness (J)	0.73	0.83	0.70	0.43	0.49	0.87	0.68	0.73	0.59
Species richness (D)	1.79	3.46	4.33	4.86	3.55	2.66	4.07	5.60	5.96

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Table 29. Wet weight (g) of cryptic species from jar samples from quarters platform 296B, winter 1978.

Platform:	QUARTERS 296B								
Leg :	EAST				WEST				
Depth :	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Heterocoel calcareous sponge							1.7	1.7	1.7
Nemertea	10.1	14.2		24.3	3.5			3.5	27.8
Platyhelminthes									
Nematoda	0.9	2.1	52.6	55.6	0.4		3.9	4.3	59.9
Cnidaria									
Anemone sp. 2		21.5	28.3	49.8		6.7	40.2	46.9	96.7
Medusa		27.3		27.3					27.3
Polychaeta									
Dodecaceria diceria									
Ctenodrilus serratus					0.4			0.4	0.4
Neanthes succinea	28.0	0.5	4.2	32.7	46.4		19.2	65.6	98.3
Phyllodocidae									
Harmothoe sp.									
Sabellaria vulgaris							2.8	2.8	2.8
Potamilla sp. 1			1.6	1.6					1.6
Eupomatus dianthus			12.2	12.2					12.2
E. protulicola							0.5	0.5	0.5
Polydora ciliata			7.3	7.3		7.8	10.8	18.6	25.9
P. colonia		56.3	2.9	59.2		2.3		2.3	61.5
Spionid sp. 3			3.2	3.2					3.2
Autolytus sp. 1	2.9	12.8		15.7					15.7
Autolytus sp. 2	4.9	63.3	16.5	84.7	3.3	10.9	3.7	17.9	102.6
Autolytus sp. 3									
Exogone dispar		0.2		0.2		0.2	0.2	0.4	0.6
Haplosyllis spongicola		0.3	13.6	13.9			40.7	40.7	54.6
Odontosyllis enopla			0.2	0.2			0.2	0.2	0.4
Synsyllis longigularis	106.2	26.5	3.4	136.1	71.0	18.7	17.7	107.4	243.5
Syllis cornuta					0.5			0.5	0.5
?*Streptosyllis* sp.					0.1			0.1	0.1
Trypanosyllis gemmipara	1.2	3.3	2.3	6.8	8.2	11.5	0.4	20.1	26.9
Syllid epitoke	0.2			0.2			0.5	0.5	0.7
Eupolymnia crassicornis									
?*Polycirrus* sp.			3.6	3.6			14.9	14.9	18.5
Oligochaeta		0.3		0.3					0.3
Pycnogonida	0.8			0.8					0.8
Crustacea									
Tanais sp.	40.6	1.3		41.9	8.1			8.1	50.0
Dynamene sp.									
Caprella equilibra	216.8		43.1	259.9	27.0		9.6	36.6	296.5
Colomastix halichondriae			8.5	8.5			0.5	0.5	9.0
Corophium sp.			9.3	9.3			39.1	39.1	48.4
Erichthonius brasiliensis			0.3	0.3		1.5	0.8	2.3	2.6
Elasmopus pectinicrus	29.3			29.3	2.2			2.2	31.5
Jassa falcata	552.0	30.8	0.5	583.3	90.9	4.3	23.1	118.3	701.6
Leucothoe spinicarpa		0.2	46.9	47.1			7.3	7.3	54.4
Stenothoe gallensis	71.6	119.0	26.6	217.2	4.6	3.6	0.8	9.0	226.2
Synalpheus fritzmuelleri		28.2		28.2					28.2
Hexapanopeus paulensis			7.1	7.1					7.1
Pseudomedaeus agassizi							29.3	29.3	29.3
Menippe mercenaria									
Gastropoda									
Doto sp.	5.3			5.3	10.4			10.4	15.7
Pelecypoda									
Anadara transversa			0.3	0.3			2.2	2.2	2.5
Arca imbricata									
Chama macerophylla		2.1	14.4	16.5					16.5
Heterodonta			0.2	0.2					0.2
Isognomon bicolor	1.7	742.0		743.7	114.9	0.5		115.4	859.1
Lithophaga aristata									
L. bisulcata	18.2	103.6	3.5	125.3	8.3	0.5	5.2	14.0	139.3
Musculus lateralis		167.4		167.4	368.6	63.1	7.9	439.6	607.0
Pteria colymbus									
Ostrea equestris						0.7		0.7	0.7
Echinodermata									
Holothuroidea		0.1	0.2	0.3			1.5	1.5	1.8
Ophiactis savignyi			10.3	10.3					10.3
Ophiothrix angulata									
Ascidiacea									
Ascidean sp. 1							18.8	18.8	18.8
TOTAL	1090.7	1423.3	323.1	2837.1	768.8	132.2	303.5	1204.6	4041.7
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Wet weight (g)/m^2	151	198	45	129	107	18	42	55	94
Number of taxa	17	23	28	41	18	14	28	38	50
Species diversity (H")	1.59	1.77	2.68	2.49	1.71	1.78	2.69	2.39	2.63
Evenness (J)	0.56	0.56	0.80	0.67	0.59	0.67	0.81	0.66	0.67
Species richness (D)	2.29	3.03	4.67	5.03	2.56	2.66	4.72	5.22	5.90

Table 30. Wet weight (g) of cryptic species from jar samples from satellite jacket 288-5, winter 1978.

Platform:	SATELLITE 288-5								
Leg :	EAST				WEST				
Depth :	S	M	B	Total	S	M	B	Total	TOTAL
TAXA									
Porifera									
Heterocoel calcareous sponge									
Nemertea	9.0	16.8		25.8	1.4	28.7		30.1	55.9
Platyhelminthes							2.8	2.8	2.8
Nematoda	0.3	0.4	0.4	1.1	0.7	0.6	0.2	1.5	2.6
Cnidaria									
Anemone sp. 2	15.8	221.4	2.8	240.0		11.2	34.7	45.9	285.9
Medusa									
Polychaeta									
Dodecaceria diceria							0.2	0.2	0.2
Ctenodrilus serratus	0.8			0.8	0.7			0.7	1.5
Neanthes succinea	265.8	345.6		611.4	139.6	233.8	4.8	378.2	989.6
Phyllodocidae									
Harmothoe sp.						16.1		16.1	16.1
Sabellaria vulgaris							9.5	9.5	9.5
Potamilla sp. 1			6.9	6.9			18.9	18.9	25.8
Eupomatus dianthus									
E. protulicola									
Polydora ciliata		29.3	3.3	32.6			6.2	6.2	38.8
P. colonia		15.8	35.9	51.7			49.5	49.5	101.2
Spionid sp. 3									
Autolytus sp. 1									
Autolytus sp. 2	2.9	0.7	0.4	4.0	2.6	0.4		3.0	7.0
Autolytus sp. 3		6.2		6.2	0.6	3.4		4.0	10.2
Exogone dispar					0.1			0.1	0.1
Haplosyllis spongicola		4.2	8.5	12.7		49.2	4.0	53.2	65.9
Odontosyllis enopla						2.2		2.2	2.2
Synsyllis longigularis			1.1	1.1		6.9	6.7	13.6	14.7
Syllis cornuta	0.1			0.1	6.0			6.0	6.1
?Streptosyllis sp.					0.1			0.1	0.1
Trypanosyllis gemmipara	0.4	31.3	0.2	31.9	9.4	2.7	6.9	19.0	50,9
Syllid epitoke					0.1			0.1	0.1
Eupolymnia crassicornis		17.3		17.3					17.3
?Polycirrus sp.							10.8	10.8	10.8
Oligochaeta									
Pycnogonida									
Crustacea									
Tanais sp.	8.3			8.3	1.9	0.4		2.3	10.6
Dynamene sp.	9.0			9.0	9.9			9.9	18.9
Caprella equilibra	152.9	1451.9	12.6	1617.4	271.5	1147.7		1419.2	3036.6
Colomastix halichondriae							0.2	0.2	0.2
Corophium sp.		6.1	99.2	105.3			123.1	123.1	228.4
Erichthonius brasiliensis		134.2	22.3	156.5		2240.5	17.6	2258.1	2414.6
Elasmopus pectenicrus	1.4			1.4	20.1	26.4		46.5	47.9
Jassa falcata	291.6	59.9	41.2	392.7	100.9	614.6	42.0	757.5	1150.2
Leucothoe spinicarpa			0.3	0.3		34.7	0.5	35.2	35.5
Stenothoe gallensis		10.1	4.5	14.6	0.3	28.7	0.3	29.3	43.9
Synalpheus fritzmuelleri									
Hexapanopeus paulensis							32.3	32.3	32.3
Pseudomedaeus agassizi						124.4		124.4	124.4
Menippe mercenaria						145.9		145.9	145.9
Gastropoda									
Doto sp.	16.9			16.9	9.1			9.1	26.0
Pelecypoda									
Anadara transversa									
Arca imbricata									
Chama macerophylla		551.6		551.6		884.9		884.9	1436.5
Heterodonta	1.6			1.6	0.1			0.1	1.7
Isognomon bicolor	414.6	11.3		425.9	598.6	115.8		714.4	1140.3
Lithophaga aristata						41.2		41.2	41.2
L. bisulcata	29.9	7.1		37.0	0.5		8.6	9.1	46.1
Musculus lateralis		216.8		216.8	488.0	254.6		742.6	959.4
Pteria colymbus	109.7	66.1		175.8					175.8
Ostrea equestris									
Echinodermata									
Holothuroidea									
Ophiactis savignyi	65.3	471.4		536.7	279.9	496.7	5.9	782.5	1319.2
Ophiothrix angulata						22.5		22.5	22.5
Ascidiacea									
Ascidean sp. 1			9.9	9.9			1.0	1.0	10.9
TOTAL	1396.3	3675.5	249.5	5321.3	1942.1	6534.2	386.7	8863.0	14184.3
Area sampled (m^2)	0.0072	0.0072	0.0072	0.022	0.0072	0.0072	0.0072	0.022	0.043
Wet weight (g)/m^2	194	510	35	242	270	908	54	403	330
Number of taxa	19	22	16	33	23	26	23	46	48
Species diversity (H")	1.91	1.96	1.89	2.32	1.78	2.07	2.31	2.38	2.47
Evenness (J)	0.65	0.64	0.68	0.66	0.57	0.64	0.74	0.62	0.64
Species richness (D)	2.49	2.56	2.72	3.73	2.91	2.85	3.69	4.95	4.92

Table 31. Results of analysis of variance on species diversity (H''_n) based on numbers of individuals of cryptic species from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	4.9174			
Platform	2	1.9059	0.9529	139.62**	0.0002
Side	1	0.0800	0.0800	11.72*	0.0267
Depth	2	1.1904	0.5952	87.21**	0.0005
Platform X Side	2	0.1147	0.0574	8.40*	0.0370
Platform X Depth	4	0.8059	0.2015	29.52**	0.0032
Side X Depth	2	0.7933	0.3967	58.12**	0.0011
Residual	4	0.0273	0.0068		

* = significant at = 0.05

** = significant at = 0.01.

Table 32. Results of analysis of variance on evenness (J_n) based on numbers of individuals of cryptic species from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	0.5169			
Platform	2	0.2487	0.1244	63.05**	0.0009
Side	1	0.0029	0.0029	1.49^{ns}	0.2892
Depth	2	0.0884	0.0442	22.42**	0.0067
Platform X Side	2	0.0027	0.0014	0.70^{ns}	0.5504
Platform X Depth	4	0.1045	0.0261	13.24*	0.0141
Side X Depth	2	0.0617	0.0308	15.64*	0.0129
Residual	4	0.0079	0.0020		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

** = significant at $\alpha = 0.01$.

Table 33. Results of analysis of variance on species richness (D_n) based on numbers of individuals of cryptic species from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	12.9952			
Platform	2	1.1332	0.5666	2.41^{ns}	0.2053
Side	1	0.0998	0.0998	0.43^{ns}	0.5500
Depth	2	5.3254	2.6627	11.34*	0.0225
Platform X Side	2	0.8156	0.4078	1.74^{ns}	0.2863
Platform X Depth	4	2.5977	0.6494	2.77^{ns}	0.1740
Side X Depth	2	2.0847	1.0423	4.44^{ns}	0.0964
Residual	4	0.9388	0.2347		

ns = not significant at $\alpha = 0.05$

* = significant at $\alpha = 0.05$.

Table 34. Results of analysis of variance on species diversity (H''_w) based on weight of cryptic species from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	3.9118			
Platform	2	0.1444	0.0722	0.89^{ns}	0.4786
Side	1	0.0939	0.0939	1.16^{ns}	0.3423
Depth	2	2.0050	1.0025	12.37*	0.0194
Platform X Side	2	0.0323	0.0162	0.20^{ns}	0.8269
Platform X Depth	4	1.2600	0.3150	3.89^{ns}	0.1085
Side X Depth	2	0.0521	0.0261	0.32^{ns}	0.7423
Residual	4	0.3241	0.0810		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

Table 35. Results of analysis of variance on evenness (J_w) based on weight of cryptic species from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	0.1857			
Platform	2	0.0136	0.0068	2.32^{ns}	0.2140
Side	1	0.0005	0.0005	0.15^{ns}	0.7153
Depth	2	0.0609	0.0305	10.39*	0.0261
Platform X Side	2	0.0114	0.0057	1.95^{ns}	0.2565
Platform X Depth	4	0.0697	0.0174	5.94^{ns}	0.0563
Side X Depth	2	0.0177	0.0089	3.02^{ns}	0.1586
Residual	4	0.0117	0.0029		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

Table 36. Results of analysis of variance on species richness (D_w) based on weight of cryptic species from jar samples, winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	17	12.1046			
Platform	2	0.7955	0.3978	1.40^{ns}	0.3451
Side	1	0.3016	0.3016	1.06^{ns}	0.3604
Depth	2	6.9727	3.4864	12.31*	0.0195
Platform X Side	2	0.2509	0.1255	0.44^{ns}	0.6703
Platform X Depth	4	1.7269	0.4317	1.52^{ns}	0.3464
Side X Depth	2	0.9241	0.4621	1.63^{ns}	0.3033
Residual	4	1.1328	0.2832		

ns = not significant at $\alpha=0.05$.

* = significant at $\alpha=0.05$.

Table 37. Results of analysis of variance on species diversity (H''_n) based on number of individuals of cryptic species from jar samples from satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	11	1.5129			
Season	1	0.4602	0.4602	13.24^{ns}	0.0679
Side	1	0.0420	0.0420	1.21^{ns}	0.3863
Depth	2	0.3153	0.1577	4.54^{ns}	0.1806
Season X Side	1	0.0954	0.0954	2.74^{ns}	0.2394
Season X Depth	2	0.1548	0.0774	2.23^{ns}	0.3099
Side X Depth	2	0.3756	0.1878	5.40^{ns}	0.1562
Residual	2	0.0695	0.0348		

ns = not significant at $\alpha = 0.05$

Table 38. Results of analysis of variance on evenness (J_n) based on numbers of individuals of cryptic species from jar samples from satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	11	0.2388			
Season	1	0.1365	0.1365	49.20*	0.0197
Side	1	0.0005	0.0005	0.19^{ns}	0.7039
Depth	2	0.0245	0.0123	4.41^{ns}	0.1850
Season X Side	1	0.0048	0.0048	1.73^{ns}	0.3190
Season X Depth	2	0.0386	0.0193	6.96^{ns}	0.1257
Side X Depth	2	0.0283	0.0142	5.10^{ns}	0.1639
Residual	2	0.0056	0.0028		

ns = not significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.05$.

Table 39. Results of analysis of variance on species richness (D_n) based on numbers of individuals of cryptic species from jar samples from satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	11	2.3734			
Season	1	0.0690	0.0690	0.13^{ns}	0.7507
Side	1	0.2611	0.2611	0.50^{ns}	0.5523
Depth	2	0.1687	0.0844	0.16^{ns}	0.8606
Season X Side	1	0.3710	0.3710	0.71^{ns}	0.4874
Season X Depth	2	0.1618	0.0809	0.16^{ns}	0.8655
Side X Depth	2	0.3007	0.1504	0.29^{ns}	0.7759
Residual	2	1.0412	0.5206		

ns = not significant at $\alpha = 0.05$.

Table 40. Results of analysis of variance on species diversity (H''_w) based on weight of cryptic species from jar samples from satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	11	0.3316			
Season	1	0.0574	0.0574	1.10^{ns}	0.4047
Side	1	0.0002	0.0002	0.00^{ns}	0.9554
Depth	2	0.0974	0.0487	0.93^{ns}	0.5178
Season X Side	1	0.0469	0.0469	0.90^{ns}	0.4437
Season X Depth	2	0.0113	0.0056	0.11^{ns}	0.9028
Side X Depth	2	0.0139	0.0069	0.13^{ns}	0.8829
Residual	2	0.1046	0.0523		

ns = not significant at $\alpha = 0.05$.

Table 41. Results of analysis of variance on evenness (J_w) based on weight of cryptic species from jar samples from satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	11	0.0349			
Season	1	0.0056	0.0056	7.43^{ns}	0.1124
Side	1	0.0027	0.0027	3.56^{ns}	0.1998
Depth	2	0.0130	0.0065	8.54^{ns}	0.1048
Season X Side	1	0.0016	0.0016	2.15^{ns}	0.2799
Season X Depth	2	0.0050	0.0025	3.31^{ns}	0.2321
Side X Depth	2	0.0055	0.0027	3.59^{ns}	0.2177
Residual	2	0.0015	0.0008		

ns = not significant at $\alpha = 0.05$.

Table 42. Results of analysis of variance on species richness (D_w) based on weight of cryptic species from jar samples from satellite jacket 288-5, summer 1977 and winter 1978.

Source	df	Sum of Squares	Mean Square	F	Pr>F
Total	11	3.5039			
Season	1	1.0150	1.0150	2.80^{ns}	0.2363
Side	1	0.0184	0.0184	0.05^{ns}	0.8427
Depth	2	0.6250	0.3125	0.86^{ns}	0.5371
Season X Side	1	0.6960	0.6960	1.92^{ns}	0.3002
Season X Depth	2	0.2797	0.1399	0.39^{ns}	0.7216
Side X Depth	2	0.1446	0.0723	0.20^{ns}	0.8337
Residual	2	0.7251	0.3626		

ns = not significant at $\alpha = 0.05$.

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Table 43. Number of individuals of cryptic species from jar samples from production platform 288A and satellite jacket 288-5 in the summer to fall recolonization period.

Colonization Period:	SUMMER TO FALL							
Structure :	Production 288A				Satellite 288-5			
Replicate No. :	1	2	3	Total	1	2	3	Total
TAXA								
Nemertea								
Nematoda	83	172	304	559	2		10	12
Anemone sp. 2							3	3
Neanthes succinea								
Autolytus sp. 1					1		3	4
Autolytus sp. 2								
Synsyllis longigularis	1		1	2				
Syllis cornuta								
Ctenodrilus serratus								
Isognomon bicolor					11	4	3	18
Musculus lateralis								
Ostrea equestris	1			1				
Doto sp.					1			1
Erichthonius brasiliensis							8	8
Elasmopus pectinicrus	1			1	9	7	8	24
Jassa falcata	9	4		13	39	46	204	289
Stenothoe gallensis						1	4	5
Caprella equilibra								
Tanais sp.	117	188	136	441	42	87	204	333
Dynamene sp.					6	9	2	17
Pycnogonida					1		2	3
Ophiactis savignyi						1	1	2
Ascidean sp. 2	5	4	7	16		1	2	3
TOTAL	217	368	448	1033	112	156	454	722
No. of Taxa	7	4	4	7	9	8	13	14
Species Diversity (H")	0.99	0.51	0.49	0.86	1.70	1.39	1.96	1.27
Evenness (J)	0.51	0.57	0.51	0.43	0.69	0.57	0.46	0.48
Species Richness (D)	1.12	0.80	0.70	0.84	1.52	1.18	1.17	1.96

Table 44. Number of individuals of cryptic species from jar samples from production platform 288A and satellite jacket 288-5 in the fall to winter recolonization period.

Colonization Period:	FALL TO WINTER							
Structure :	Production 288A				Satellite 288-5			
Replicate No. :	1	2	3	Total	1	2	3	Total
TAXA								
Nemertea					9		1	10
Nematoda	27	99	5	131	88	96	4	188
Anemone sp. 2								
Neanthes succinea								
Autolytus sp. 1								
Autolytus sp. 2						1		1
Synsyllis longigularis								
Syllis cornuta								
Ctenodrilus serratus								
Isognomon bicolor		1		1				
Musculus lateralis	1			1				
Ostrea equestris								
Doto sp.		3		3	19	1	3	23
Erichthonius brasiliensis								
Elasmopus pectinicrus								
Jassa falcata	14	64	3	81	1052	1600	1208	3860
Stenothoe gallensis					20			20
Caprella equilibra	20	37	13	70	188	192	44	424
Tanais sp.	1	10		11	8			8
Dynamene sp.	6	2	14	22				
Pycnogonida		1		1	16	1	3	20
Ophiactis savignyi								
Ascidean sp. 2								
TOTAL	69	217	35	321	1400	1891	1263	4554
No. of Taxa	6	8	4	9	8	6	6	9
Species Diversity (H")	1.18	1.30	0.84	1.39	0.97	0.66	0.70	0.59
Evenness (J)	0.77	0.63	0.88	0.66	0.43	0.30	0.12	0.27
Species Richness (D)	1.38	1.31	1.22	1.44	0.89	0.54	0.21	0.95

Table 45. Number of individuals of cryptic species from jar samples from production platform 288A and satellite jacket 288-5 in the summer to winter recolonization period.

Colonization Period:	SUMMER TO WINTER							
Structure :	Production 288A				Satellite 288-5			
Replicate No. :	1	2	3	Total	1	2	3	Total
TAXA								
Nemertea					8	39	8	55
Nematoda	9	20	2	31	4	39	10	53
Anemone sp. 2							3	3
Neanthes succinea							1	1
Autolytus sp. 1								
Autolytus sp. 2					1	6	5	12
Synsyllis longigularis								
Syllis cornuta					5	2		7
Ctenodrilus serratus							1	1
Isognomon bicolor	1	3		4	5	10	7	22
Musculus lateralis					1	1		2
Ostrea equestris								
Doto sp.								
Erichthonius brasiliensis								
Elasmopus pectenicrus					20	5		25
Jassa falcata	3	21	3	27	738	71	155	964
Stenothoe gallensis					1			1
Caprella equilibra	18	103	11	132	45	2	12	59
Tanais sp.	1	5		6	24	3	5	32
Dynamene sp.	5	5	5	15	1		11	12
Pycnogonida								
Ophiactis savignyi								
Ascidean sp. 2					1			1
TOTAL	37	157	21	215	854	178	218	1250
No. of Taxa	6	6	4	6	13	10	11	16
Species Diversity (H")	1.36	0.99	0.99	0.93	1.78	1.74	1.86	2.10
Evenness (J)	0.76	0.62	0.85	0.67	0.25	0.70	0.50	0.37
Species Richness (D)	1.38	1.10	1.18	1.20	0.64	1.61	1.21	1.02

Table 46. **Wet weight (g) of cryptic species from jar samples from production platform 288A and satellite jacket 288-5 in the summer to fall recolonization period.**

Colonization Period:	SUMMER TO FALL							
Structure :	Production 288A				Satellite 288-5			
Replicate No. :	1	2	3	Total	1	2	3	Total
TAXA								
Nemertea								
Nematoda	0.3	0.8	1.2	2.3	0.1		0.1	0.2
Anemone sp. 2							3.1	3.1
Neanthes succinea								
Autolytus sp. 1					0.5		0.5	1.0
Autolytus sp. 2								
Synsyllis longigularis	0.1		0.3	0.4				
Syllis cornuta								
Ctenodrilus serratus								
Isognomon bicolor					11.3	5.9	9.9	27.1
Musculus lateralis								
Ostrea equestris	0.6			0.6				
Doto sp.					0.7			0.7
Erichthonius brasiliensis							0.4	0.4
Elasmopus pectenicrus	0.3			0.3	5.7	9.7	0.8	16.2
Jassa falcata	1.3	0.8		2.1	11.4	4.2	27.2	42.8
Stenothoe gallensis						0.1	0.8	0.9
Caprella equilibra								
Tanais sp.	11.2	27.6	16.0	54.8	3.4	5.3	12.8	21.5
Dynamene sp.					0.1	35.7	4.5	40.3
Pycnogonida					0.8		0.7	1.5
Ophiactis savignyi						2.3	4.6	6.9
Ascidean sp. 2	0.6	0.7	6.2	7.5		0.4	0.1	0.5
TOTAL	14.4	29.9	23.7	68.0	34.0	63.6	65.5	163.1
No. of Taxa	7	4	4	7	9	8	13	14
Species Diversity (H")	0.87	0.88	0.95	1.42	2.27	1.69	2.87	2.55
Evenness (J)	0.45	0.26	0.59	0.38	0.69	0.65	0.67	0.71
Species Richness (D)	2.25	0.36	0.82	0.73	1.53	1.35	1.73	1.87

Table 47. Wet weight (g) of cryptic species from jar samples from production platform 288A and satellite jacket 288-5 in the fall to winter recolonization period.

Colonization Period:	FALL TO WINTER							
Structure :	Production 288A				Satellite 288-5			
Replicate No. :	1	2	3	Total	1	2	3	Total
TAXA								
Nemertea					2.8		0.2	3.0
Nematoda	0.2	0.6	0.1	0.9	0.8	1.6	0.1	2.5
Anemone sp. 2								
Neanthes succinea								
Autolytus sp. 1								
Autolytus sp. 2						0.1		0.1
Synsyllis longigularis								
Syllis cornuta								
Ctenodrilus serratus								
Isognomon bicolor		0.3		0.3				
Musculus lateralis	8.5			8.5				
Ostrea equestris								
Ioto sp.		1.7		1.7	11.8	0.3	0.5	12.6
Erichthonius brasiliensis								
Elasmopus pectenicrus								
Jassa falcata	52.2	150.3	6.9	217.4	881.2	115.2	397.0	1393.4
Stenothoe gallensis					16.8			16.8
Caprella equilibra	40.5	103.1	15.9	159.5	150.0	97.6	48.4	296.0
Tanais sp.	0.1	4.3		4.6	1.6			1.6
Dynamene sp.	1.0	1.4	6.4	8.8				
Pycnogonida		0.4		0.4	5.6	7.9	0.7	14.2
Ophiactis savignyi								
Ascidean sp. 2								
TOTAL	102.7	270.1	29.3	402.1	1070.6	222.7	446.9	1740.2
No. of Taxa	6	8	4	9	8	6	6	9
Species Diversity (H")	0.99	0.84	1.02	1.33	0.61	0.87	0.37	0.63
Evenness (J)	0.55	0.40	0.74	0.44	0.29	0.48	0.21	0.29
Species Richness (D)	1.08	1.25	0.89	0.96	1.00	0.92	0.82	1.07

Table 48. Wet weight (g) of cryptic species from jar samples from production platform 288A and satellite jacket 288-5 in the summer to winter recolonization period.

Colonization Period:	SUMMER TO WINTER							
Structure :	Production 288A				Satellite 288-5			
Replicate No. :	1	2	3	Total	1	2	3	Total
TAXA								
Nemertea					3.0	0.6	2.0	5.6
Nematoda	0.1	0.3	0.1	0.5	0.1	0.3	0.1	0.5
Anemone sp. 2							15.6	15.6
Neanthes succinea							103.0	103.0
Autolytus sp. 1								
Autolytus sp. 2					0.3	1.8	1.7	3.8
Synsyllis longigularis								
Syllis cornuta					0.6	0.7		1.3
Ctenodrilus serratus							0.2	0.2
Isognomon bicolor	0.5	1.6		2.1	109.7	560.6	106.1	776.4
Musculus lateralis					32.7	80.2		112.9
Ostrea equestris								
Doto sp.								
Erichthonius brasiliensis								
Elasmopus pectinicrus					88.0	39.9		127.9
Jassa falcata	5.0	8.9	0.6	14.5	203.0	78.6	109.0	390.6
Stenothoe gallensis					0.2			0.2
Caprella equilibra	8.4	95.3	4.5	108.2	27.9	6.9	31.1	65.9
Tanais sp.	0.2	1.4		1.6	3.6	2.3	2.6	8.5
Dynamene sp.	23.7	25.8	10.1	59.6	15.2		82.6	97.8
Pycnogonida								
Ophiactis savignyi								
Ascidean sp. 2					0.3			0.3
TOTAL	37.9	133.3	15.3	186.5	484.6	771.9	454.0	1710.5
No. of Taxa	6	6	4	6	13	10	11	16
Species Diversity (H")	1.38	1.02	1.10	0.99	1.94	1.35	1.63	1.64
Evenness (J)	0.56	0.48	0.57	0.55	0.61	0.41	0.71	0.59
Species Richness (D)	1.00	0.85	0.79	0.96	1.56	0.94	1.71	2.01

Table 49. Gross seasonal production estimates (g/m^2/day) of the fouling community from (A) template and jar samples at satellite jacket 288-5, and from (B) recolonization samples at production platform 288A and satellite jacket 288-5.

A. SATELLITE 288-5: SUMMER TO WINTER

	TOTAL WEIGHT				MAT WEIGHT			
Samples:	Template		Jar		Template		Jar	
Leg:	East	West	East	West	East	West	East	West
Depth								
Surface	+29	+39	+42	+30	+12	+27	+ 4	+ 9
Midwater (8m)	+36	+85	+26	+50	+21	+53	+11	+31
Bottom (18m)	+ 4	+ 4	- 2	- 6	-0.3	-0.9	- 1	- 5

B.

	SUMMER TO FALL		FALL TO WINTER		SUMMER TO WINTER	
	P 288A	S 288-5	P 288A	S 288-5	P 288A	S 288-5
Total Biomass	38	77	10	16	9	62
Barnacles	33	68	7	4	8	56
Mat	5	9	3	12	1	6

Table 50. Results of food habit investigations of the Atlantic spadefish performed during winter 1978.

				Stomach Contents (%)									
Fish No.	Date (1978)	Time	Structure	Unidentified	*Tubularia crocea*	Hyperiidea	Copepoda	Ostracoda	Barnacle molt	Hydroid	Stomach Contents Weight (g)	Fish Weight (g)	Stomach Fullness Index
1	12 Mar	1615-1630	Q 296B	100			P				0.57	872	6.5
2				100							1.16	2120	5.5
3					100						0.71	514	13.8
4				20	80						1.36	912	14.9
5				100							0.30	939	3.2
7				100							0.33	1109	3.0
8				50	50				P		0.39	745	5.2
9				100							0.82	802	10.2
11				100							0.28	1145	2.4
12				10	90		P				0.45	820	5.5
13				100							0.39	820	4.8
14				100							0.34	810	4.2
15				100							0.58	814	7.1
16				100							0.03	343	0.9
17				80					20		0.19	651	2.9
18				100							0.06	391	1.5
19				100			P				2.25	1041	21.6
20				100							0.05	713	0.7
21				100							0.12	811	1.5
22				100							0.25	630	4.0
23	13 Mar	0811-0841	P 296B								0	732	0
24				100							0.10	1050	1.0
25				100							0.06	940	0.6
26				100							0.58	1205	4.8
27				100							0.53	1000	5.3
28				100							0.17	881	1.9
29					100*						6.01	1029	58.4
30					100*						2.10	909	23.1
31				100							0.31	794	3.9
32				100							0.11	1097	1.0
33					100*		P				13.35	980	136.2
34					100*		P				7.94	961	82.6
35					100*		P				2.75	950	28.9
36				100							0.07	1401	0.5
37					20*				80	P	1.17	731	16.0
38					100*		P				9.87	822	120.1
39				100							0.25	3136	0.8
40	15 Mar	1207-1222	S 288-5		100**						1.49	875	17.0
41					100**	P					7.47	532	140.4
42					100**	P					12.43	1134	112.3
43					100**	P					3.63	749	48.5
44					100**			P			0.43	964	4.5
45					100**						0.60	2826	2.1
46					100**	P					4.77	752	63.4
47					100**		P				2.12	760	27.9
48					100**						4.67	831	56.2
49					100**						0.47	950	4.9
50					100**	P	P				2.93	665	44.1
51					100**						5.72	980	58.4
52					100**	P					0.88	530	16.6
53					100**	P					3.87	752	51.5
54					100**	P					3.65	991	36.8
55					100**	P					10.71	810	132.2
56					100**	P					3.93	705	55.7
57					100**	P					8.58	538	159.5
58					100**	P					3.68	868	42.4
59					100**	P					2.59	590	43.9
60					100**						1.04	3271	3.2
61					100**		P				7.78	1040	74.8
62					100**	P					17.37	697	249.2
63					100**	P					2.65	432	61.3
64				100							0.25	794	3.1
65					100**						1.49	1337	11.1

*undigested; **partially digested
P = Present

APPENDIX III.

FIGURES

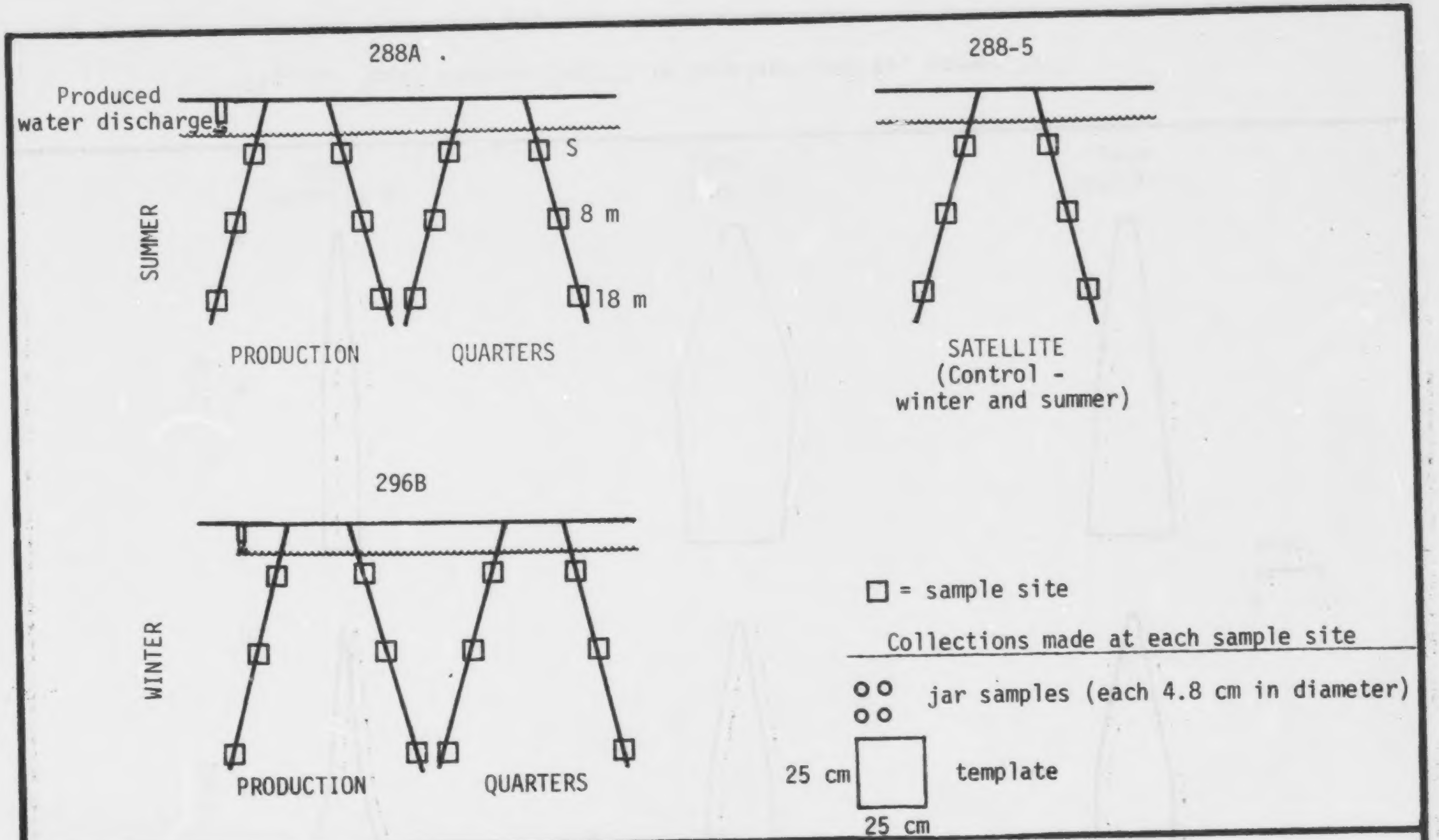

288A
Produced water discharge
S
8 m
18 m
SUMMER
PRODUCTION
QUARTERS
288-5
SATELLITE (Control - winter and summer)
296B
WINTER
PRODUCTION
QUARTERS
□ = sample site
Collections made at each sample site
jar samples (each 4.8 cm in diameter)
25 cm
template
25 cm

Fig. 1. Diagrammatic representation of sampling locations on each platform type investigated.

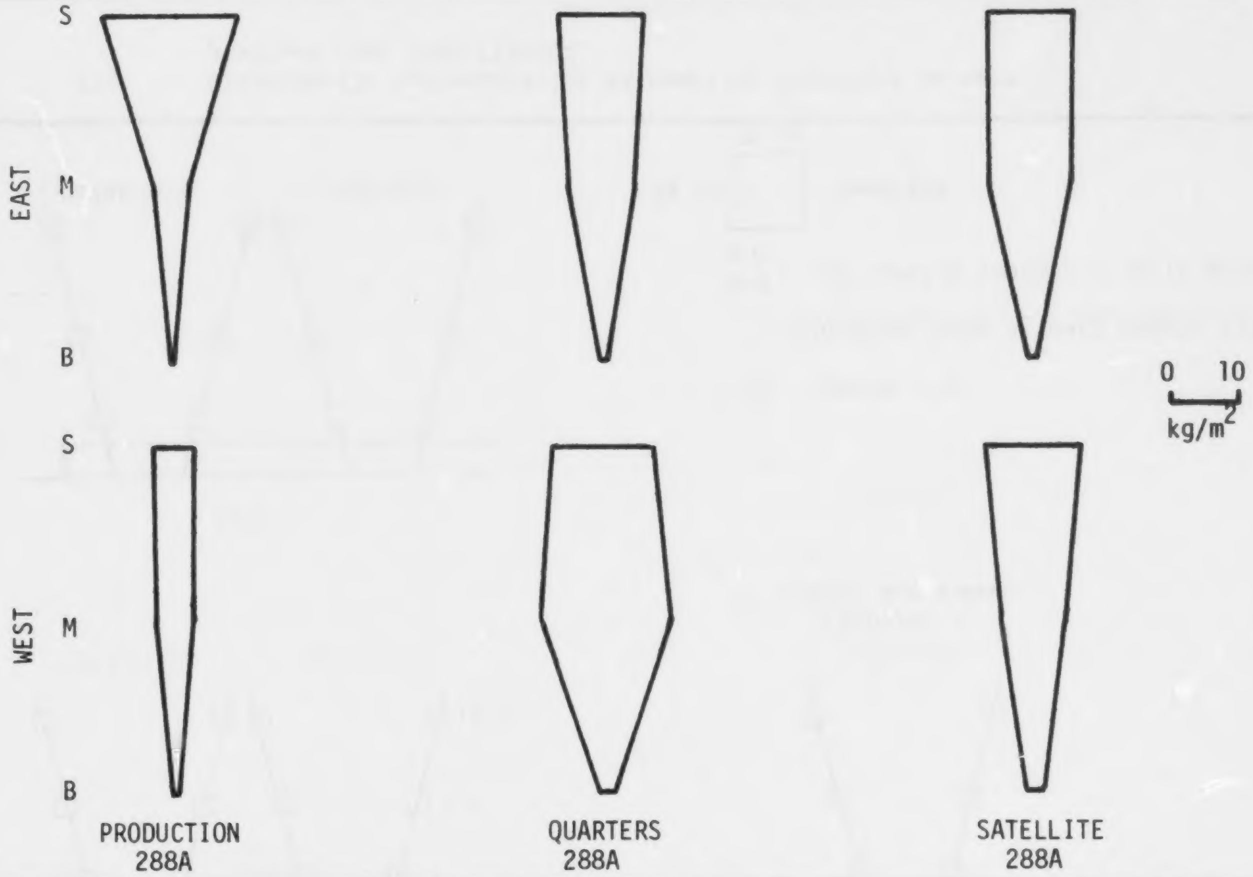


Fig. 2. Total biomass (kg/m^2) in template samples, summer 1977.

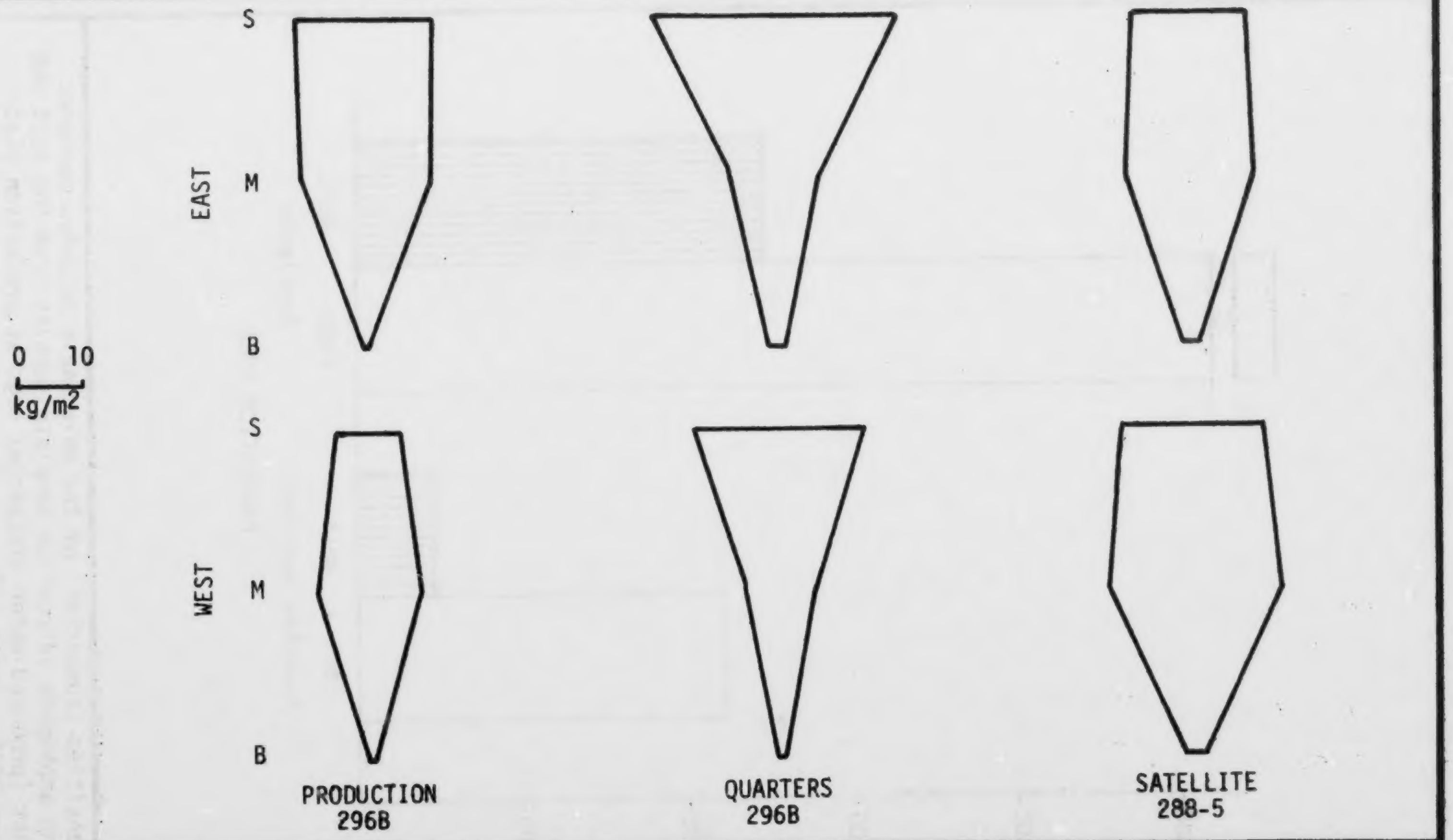


Fig. 3. Total biomass (kg/m^2) in template samples, winter 1978.

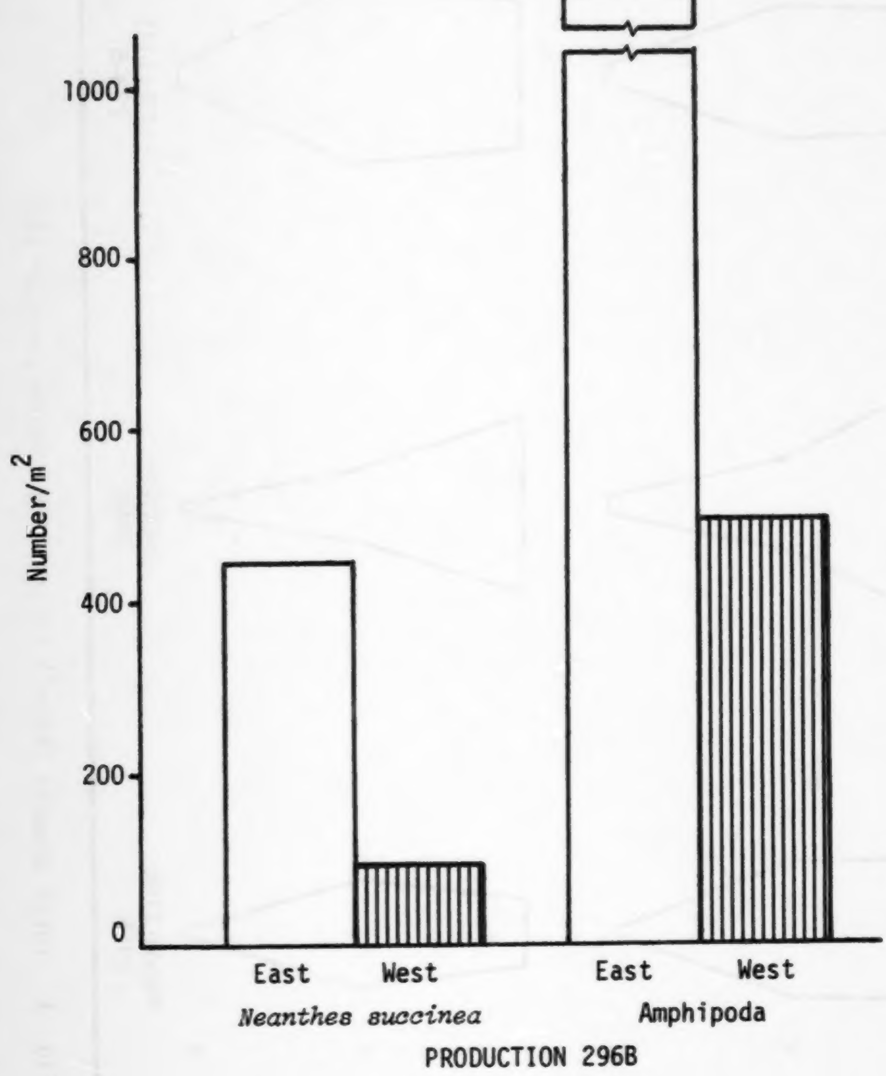


Fig. 4. Densities (number/m^2) of the polychaete *Neanthes succinea* and amphipods in surface template samples from the east and west (produced water discharge) legs at production platform 296B, winter 1978.

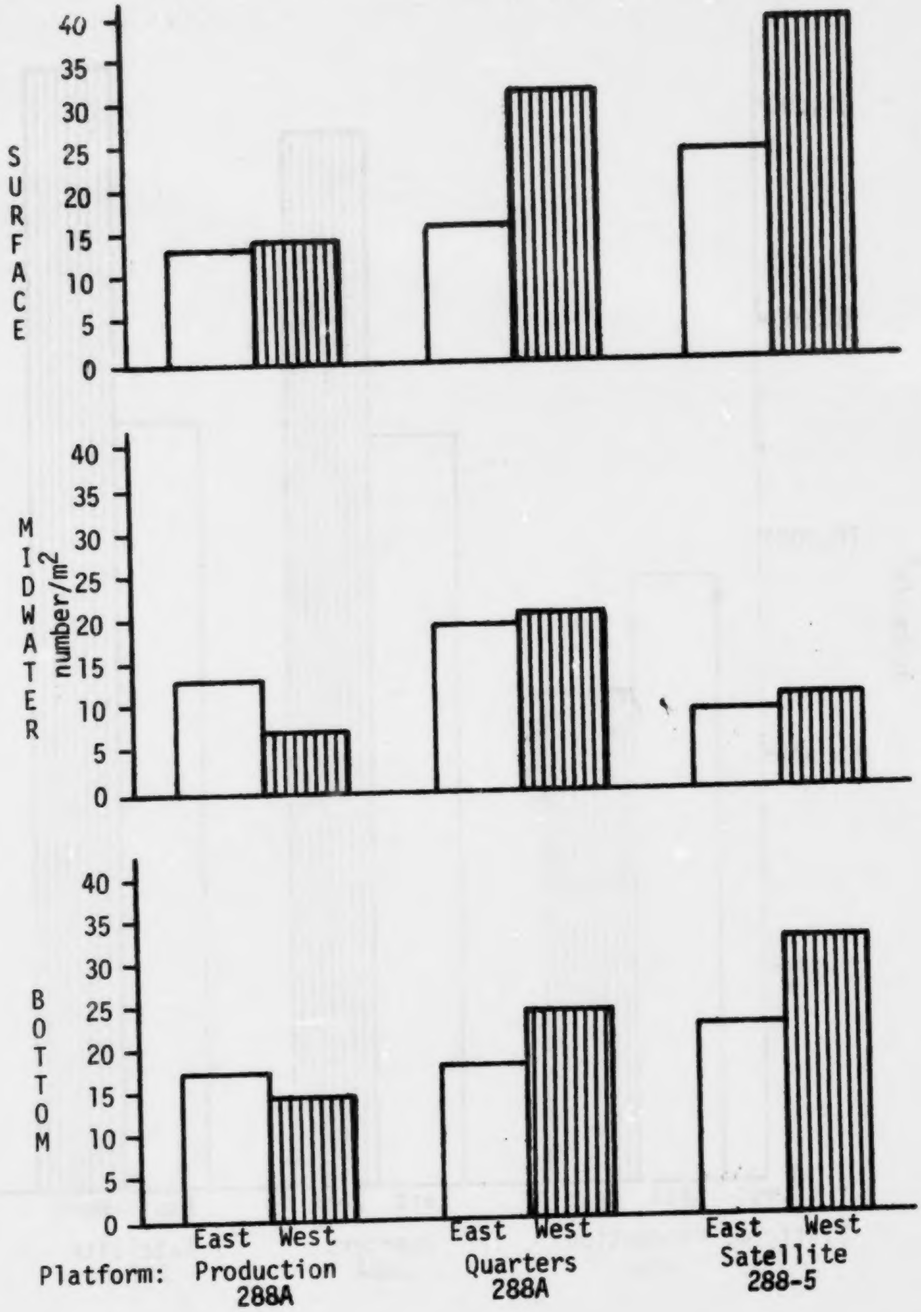


Fig. 5. Densities (total number/m^2) of cryptic species from jar samples, summer 1977.

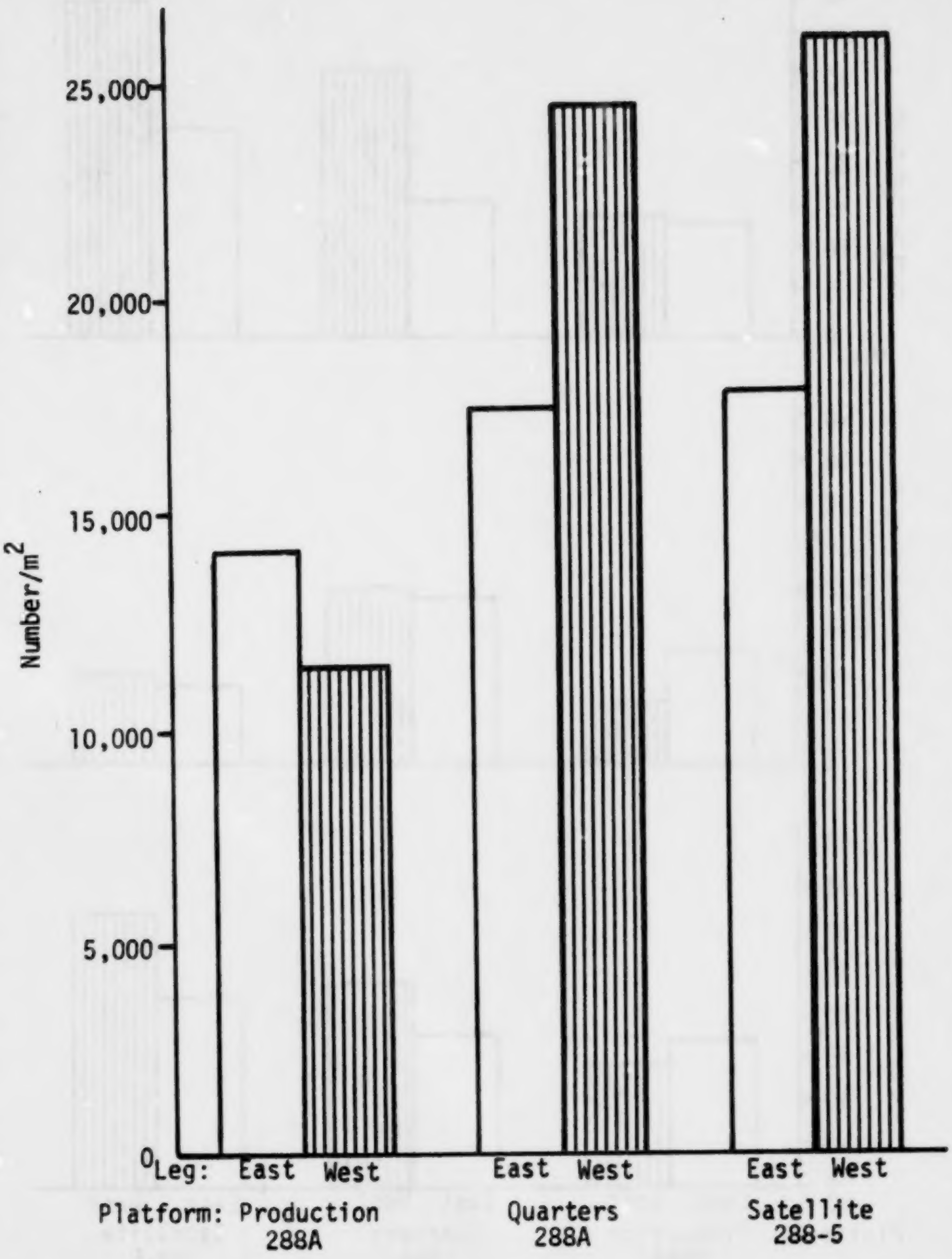


Fig. 6. Densities (total number/m^2) of cryptic species from jar samples from each leg of the production, quarters, and satellite platforms, summer 1977.

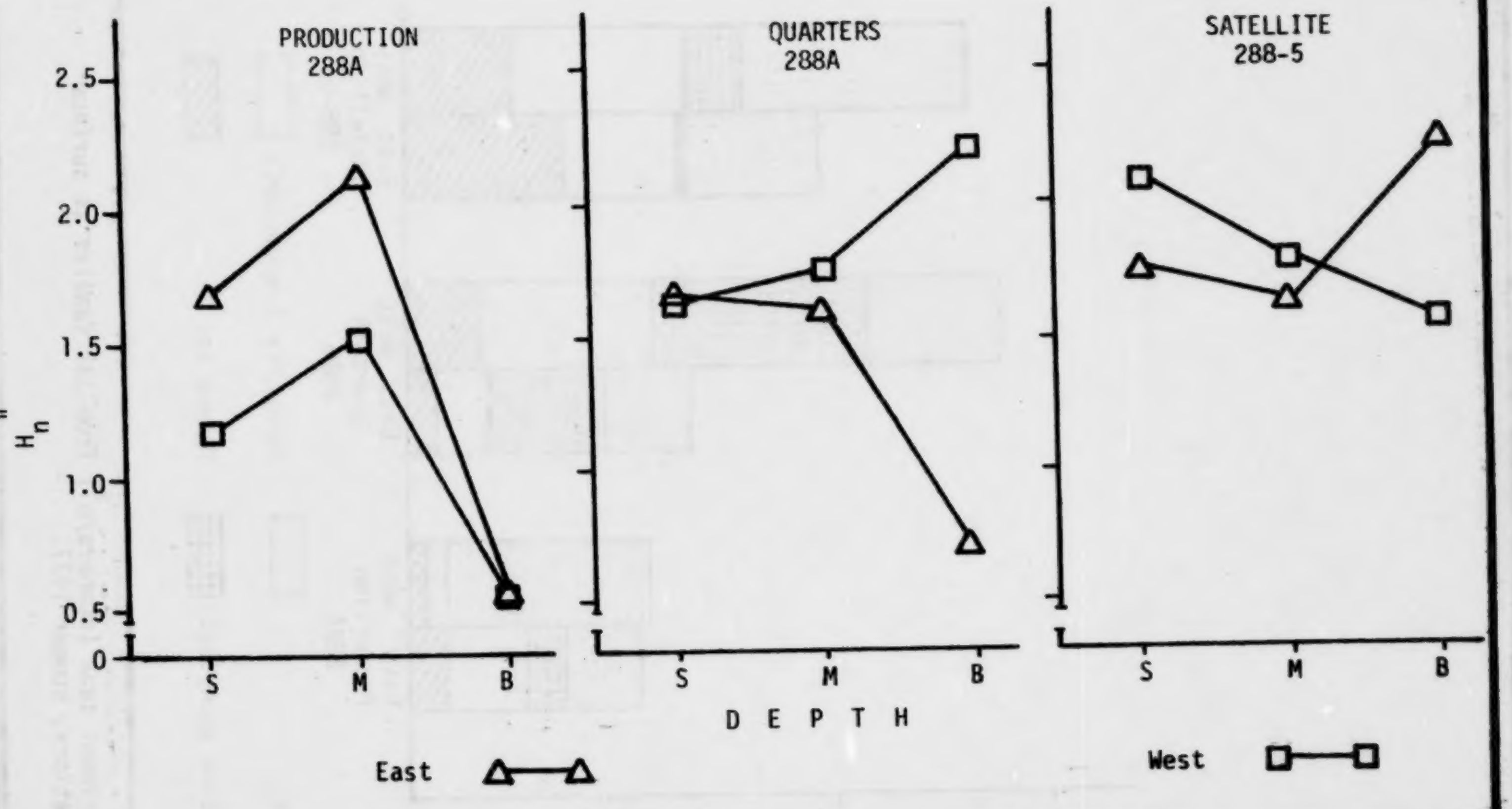


Fig. 7. Species diversity (H_n'') based on numbers of individuals of cryptic species from jar samples, summer 1977.

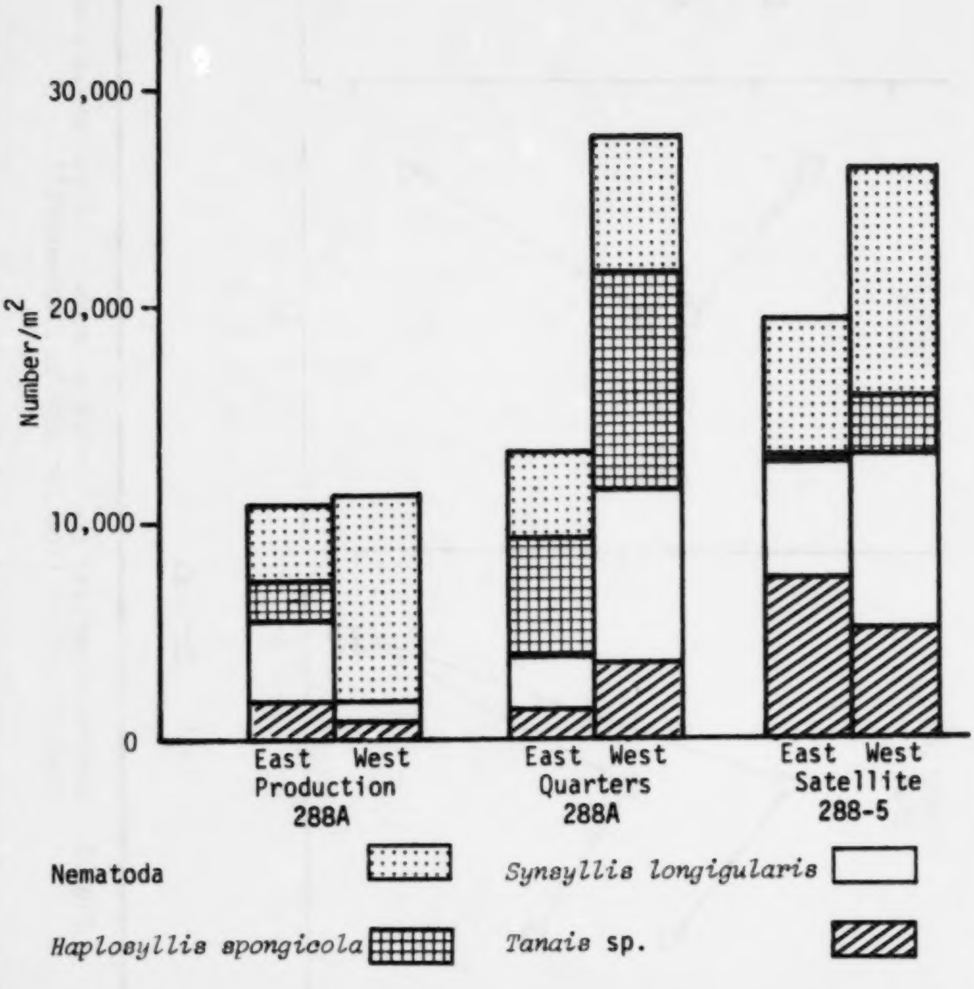


Fig. 8. Dominant taxa (numbers/m^2) from jar samples at surface stations, summer 1977.

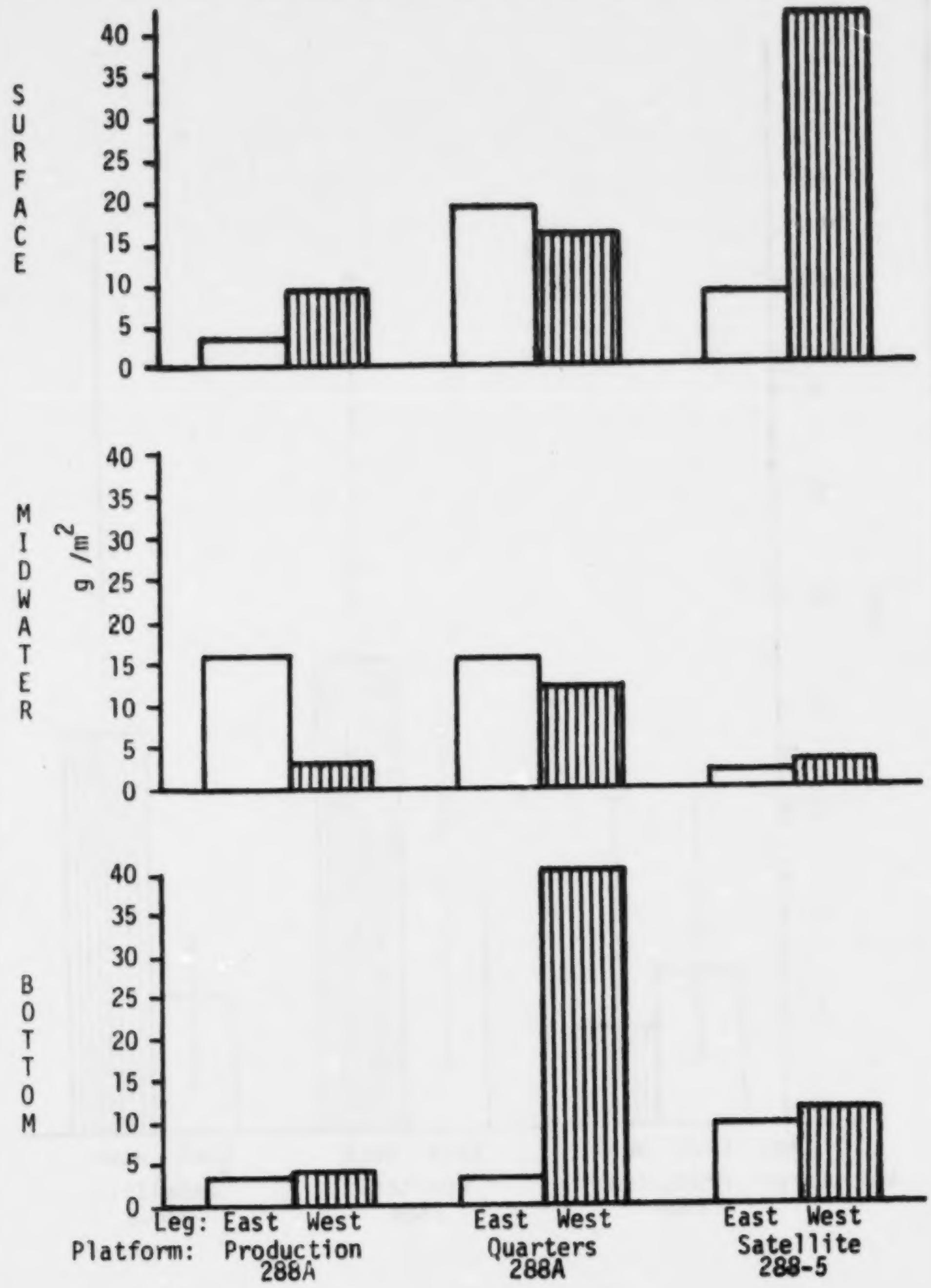


Fig. 9. Total biomass (g/m^2) of cryptic species from jar samples, summer 1977.

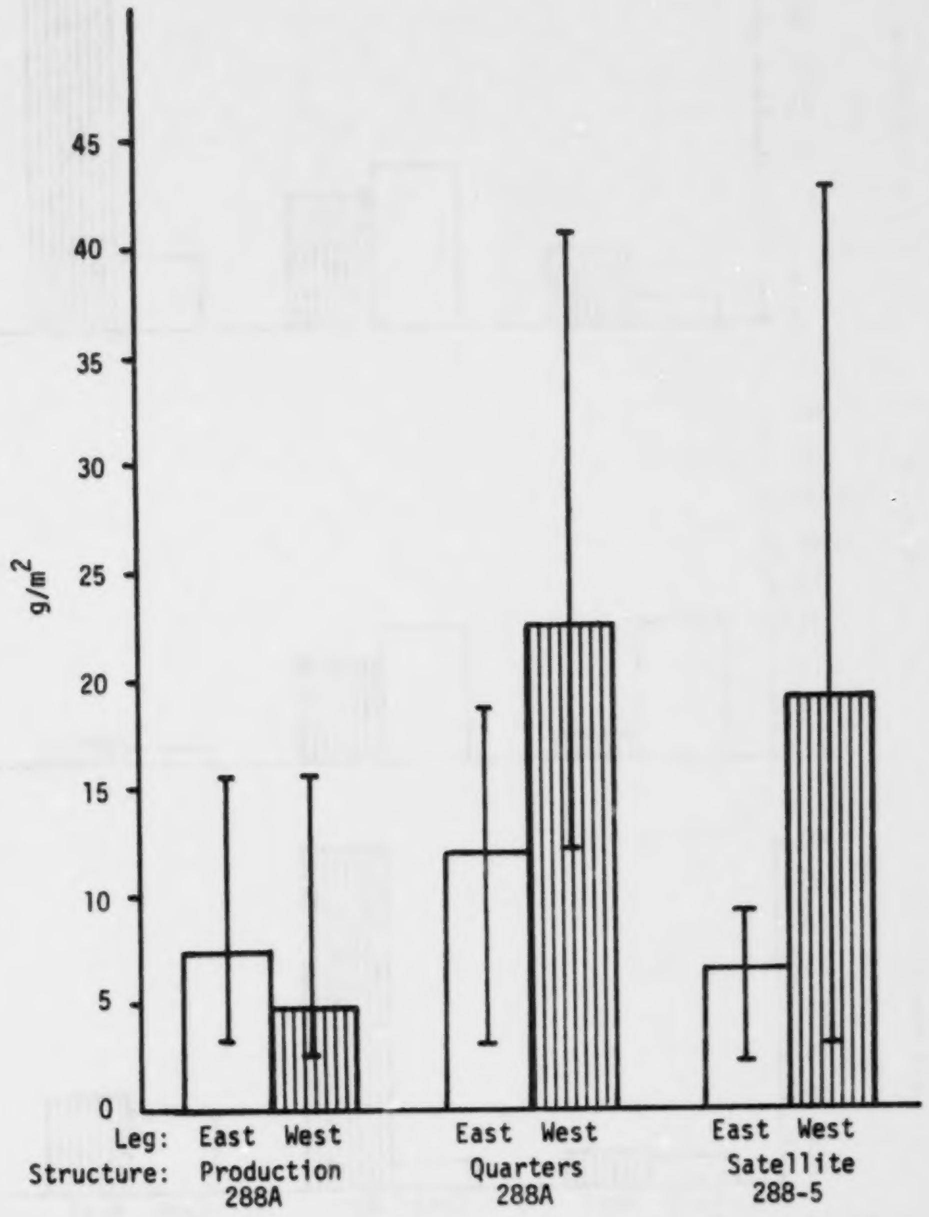


Fig. 10. Total biomass (g/m^2) and range of cryptic species from jar samples from each leg of production, quarters, and satellite platforms, summer 1977.

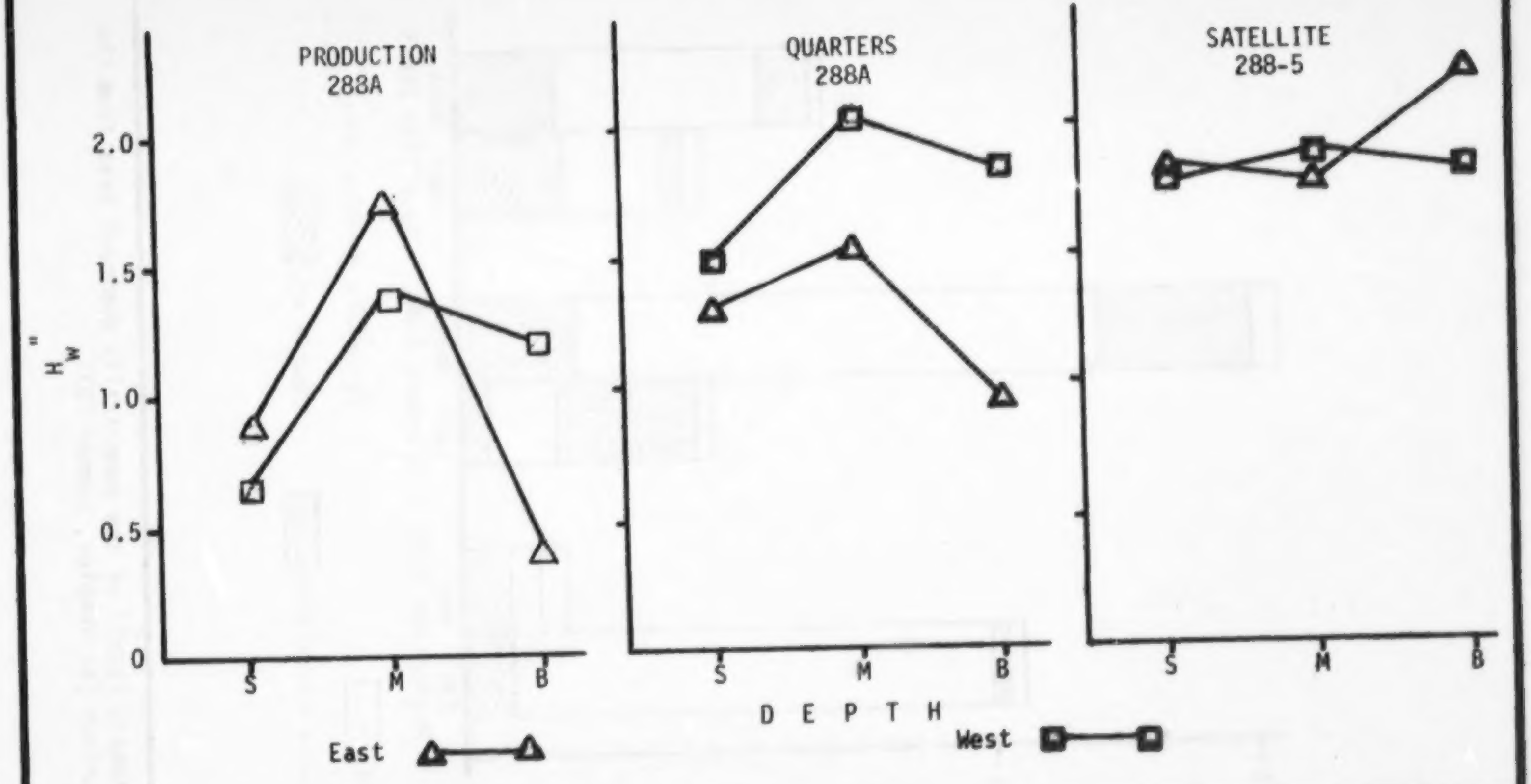


Fig. 11. Species diversity (H''_w) based on weight of cryptic species from jar samples, summer 1977.

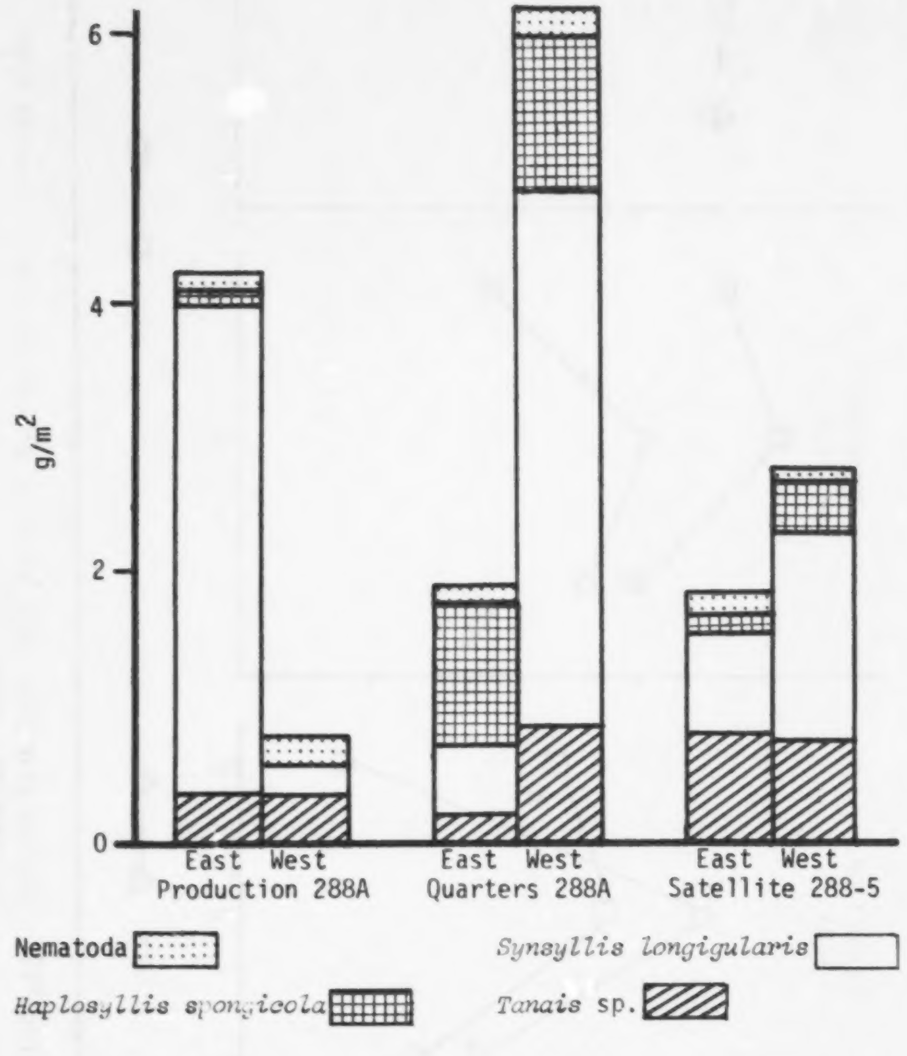


Fig. 12. Biomass (g/m^2) of the numerically dominant taxa from the surface jar samples, summer 1977.

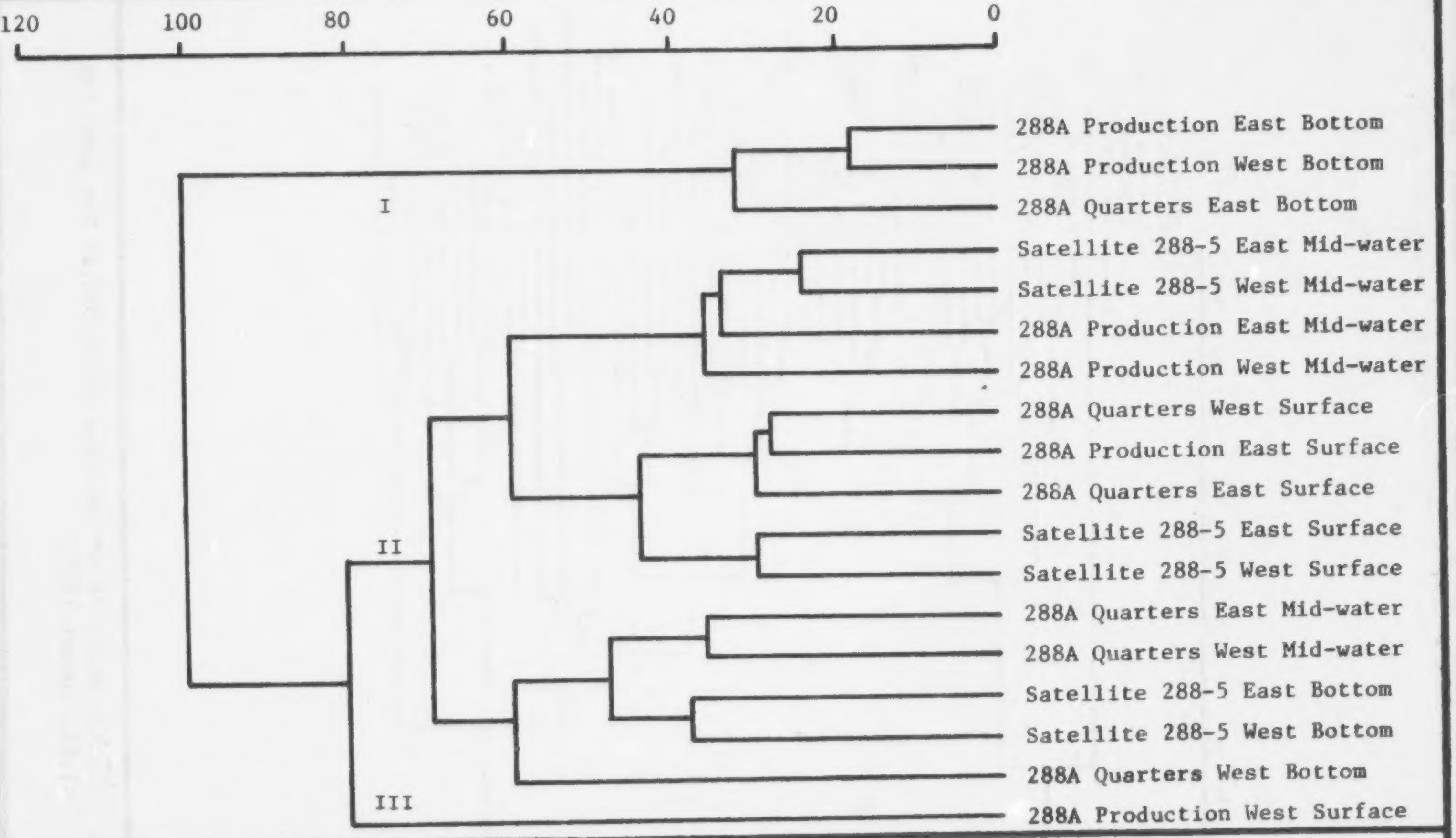


Fig. 13. Cluster analysis of the locations of sample collections, summer 1977.

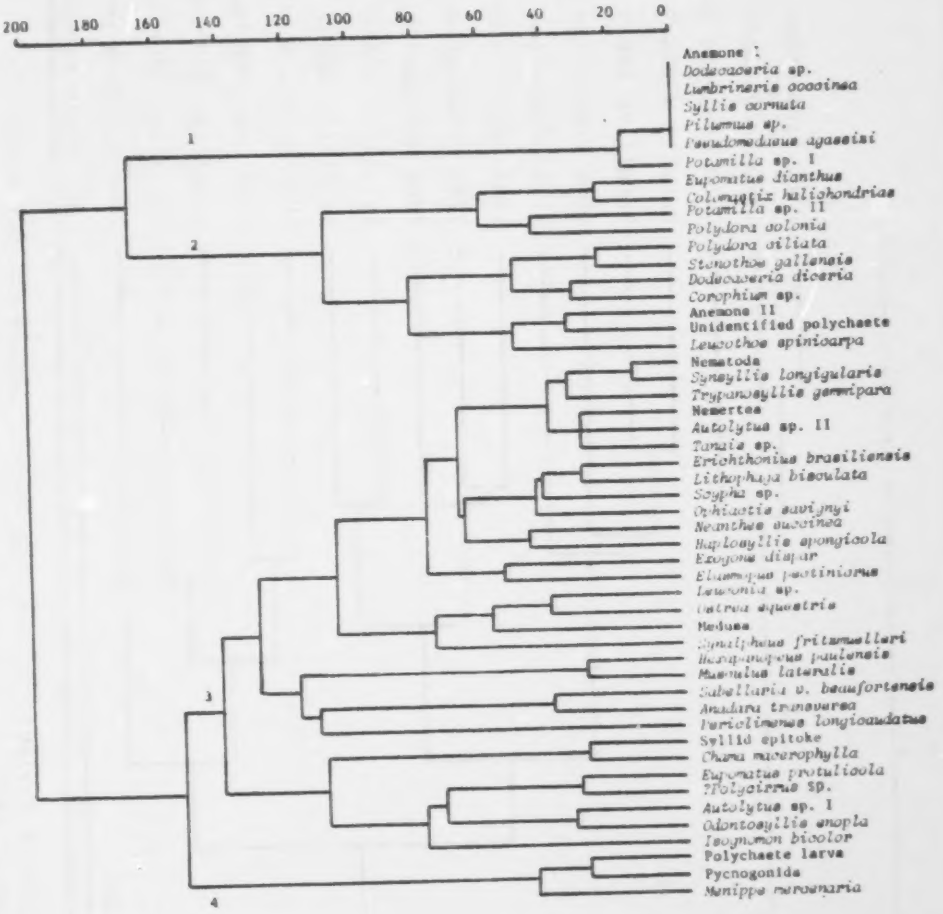


Fig. 14. Cluster analysis of the taxa collected at the sampling sites, summer 1977.

	288A Production East Bottom	288A Production West Bottom	288A Quarters East Bottom	Satellite 288-5 East Mid-water	Satellite 288-5 West Mid-water	288A Production East Mid-water	288A Production West Mid-water	288A Quarters West Surface	288A Production East Surface	288A Quarters East Surface	Satellite 288-5 East Surface	Satellite 288-5 West Surface	288A Quarters East Mid-water	288A Quarters West Mid-water	Satellite 288-5 East Bottom	Satellite 288-5 West Bottom	288A Quarters West Bottom	288A Production West Surface
Anemone I																	*	
Dodecaceria sp.																	*	
Lumbrineris coccinea																	*	
Syllis cornuta																	*	
Pilumnus sp.																	*	
Pseudomedaeus agassizi																	*	
Potamilla sp. I			*														*	
Eupomatus dianthus																*	*	
Colomastix halichondriae				*												*	*	
Potamilla sp. II																*		
Polydora colonia	*	*											*	*	*	*		
Polydora ciliata															*		*	
Stenothoe gallensis															*		*	
Dodecaceria diceria			*			*									*	*	*	
Corophium sp.		*	*						*						*	*	*	
Anemone II															*	*		
Unidentified polychaete														*				
Leucothoe spinicarpa					*						*		*		*	*		
Nematoda	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Synsyllis longigularis	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Trypanosyllis gemmipara					*	*		*		*	*	*	*	*	*	*	*	
Nemertea				*	*	*		*	*		*	*			*			
Autolytus sp. II	*			*	*	*		*	*	*	*	*		*	*		*	
Tanais sp.				*	*	*		*	*	*	*	*		*				*
Erichthonius brasiliensis											*	*	*	*	*			
Lithophaga bisculata						*					*	*	*	*				
Scypha sp.					*	*	*					*	*	*				
Ophiactis savignyi				*	*	*	*			*	*	*	*	*				
Neanthes succinea			*			*						*	*	*	*	*		
Haplosyllis spongicola	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Exogone dispar											*	*						
Elasmopus pectinicrus								*	*	*		*		*		*	*	
Leuconia sp.						*						*						
Ostrea equestris						*												
Medusa						*		*	*									
Synalpheus fritzmuelleri				*		*	*			*		*					*	
Hexapanopeus paulensis														*				
Musculus lateralis												*		*				
Sabellaria v. beaufortensis			*															
Anadara transversa			*									*						
Periclimenes longicaudatus		*																
Syllid epitoke								*										
Chama macerophylla								*					*					
Eupomatus protulicola				*	*								*					
?Polycirrus sp.				*									*		*			
Autolytus sp. I						*	*						*	*	*			*
Odontosyllis enopla					*	*	*						*		*			
Isognomon bicolor									*		*		*					
Polychaete larva																		*
Pycnogonida												*						*
Menippe mercenaria										*								*

Fig. 15. Two-way table illustrating the relationship between the taxa and the locations of sample collections, summer 1977.

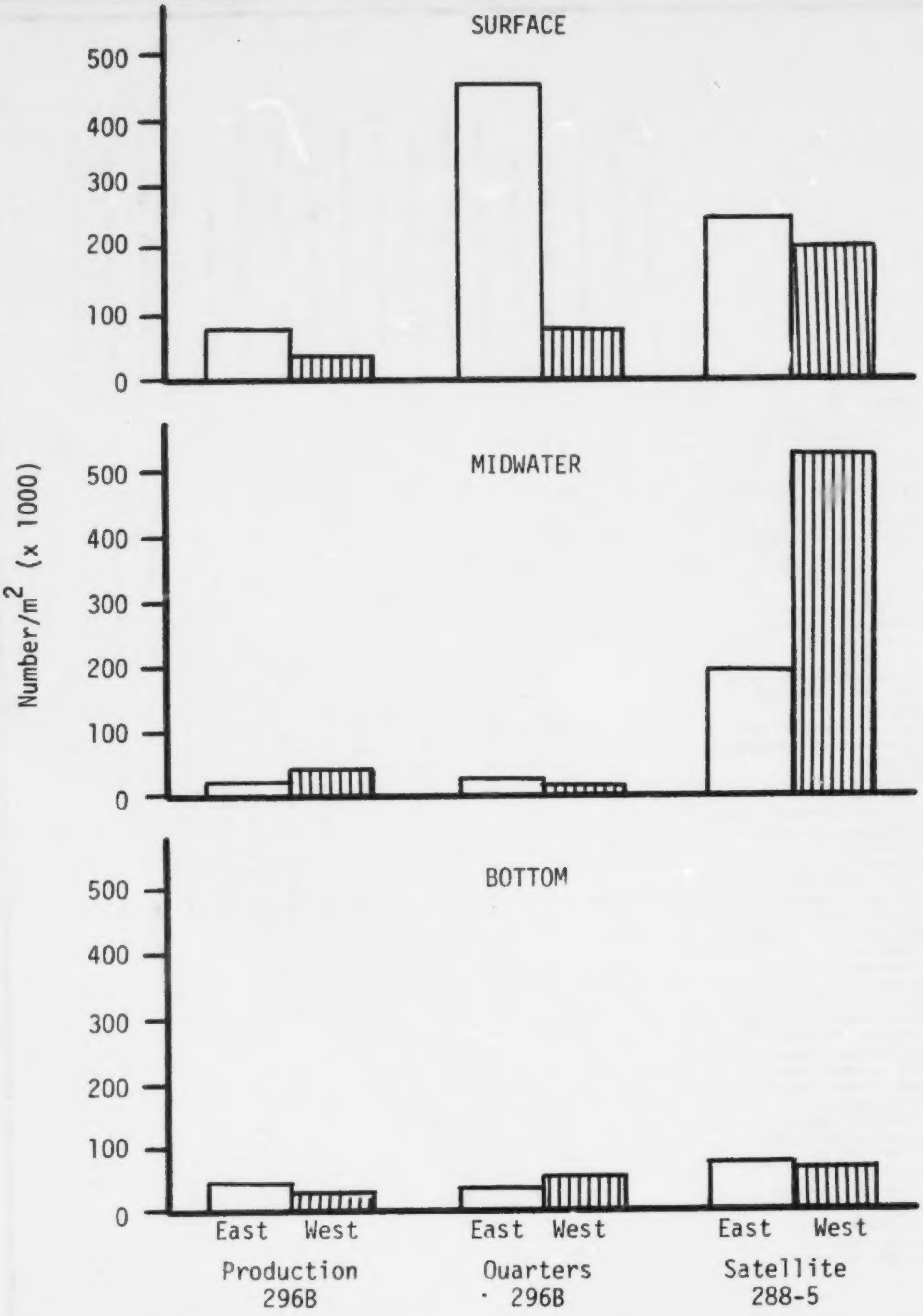


Fig. 16. Densities (total number/m^2) of cryptic species from jar samples, winter 1978.

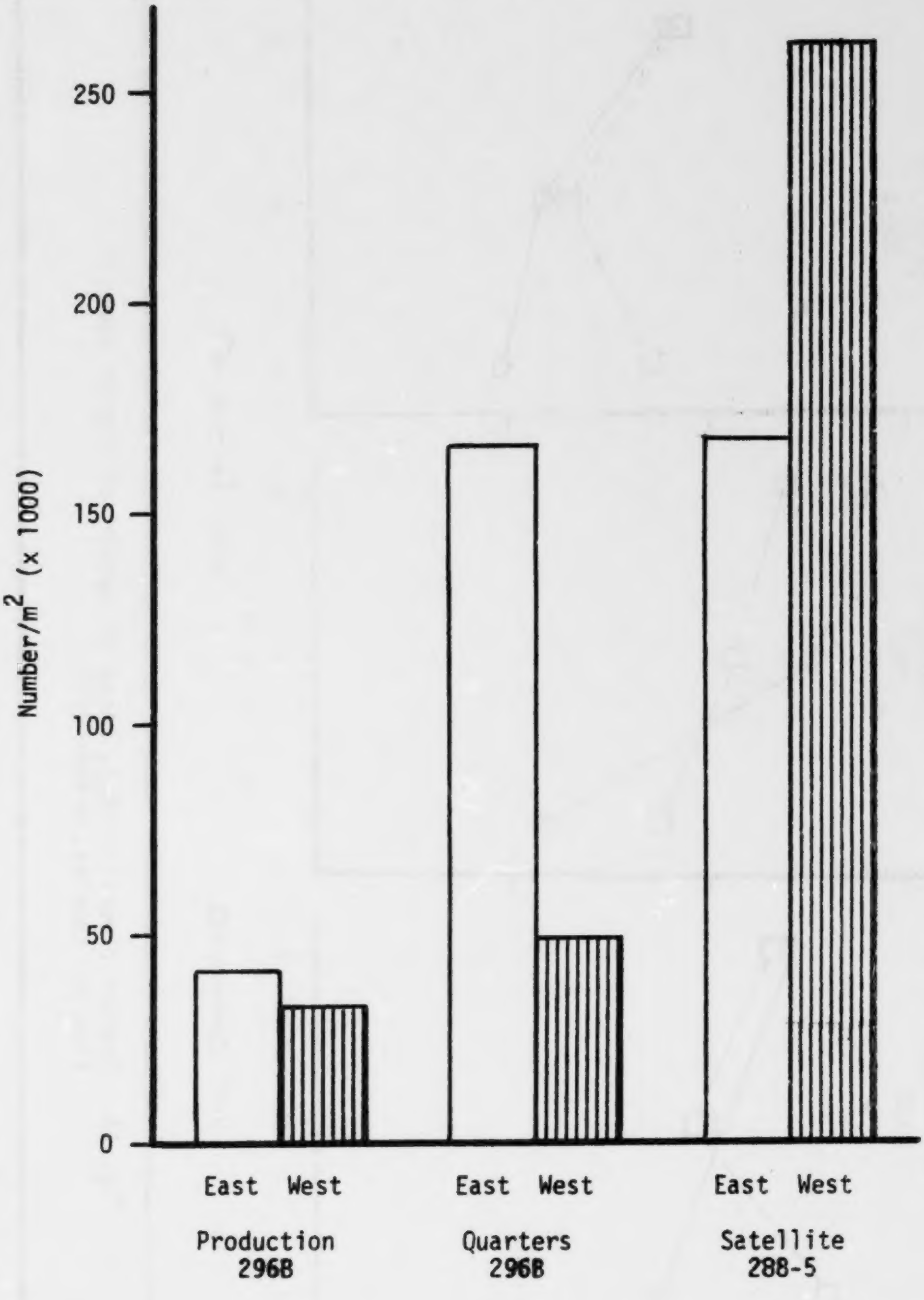


Fig. 17. Densities (total number/m^2) of cryptic species from jar samples from each leg of the production, quarters, and satellite platforms, winter 1978.

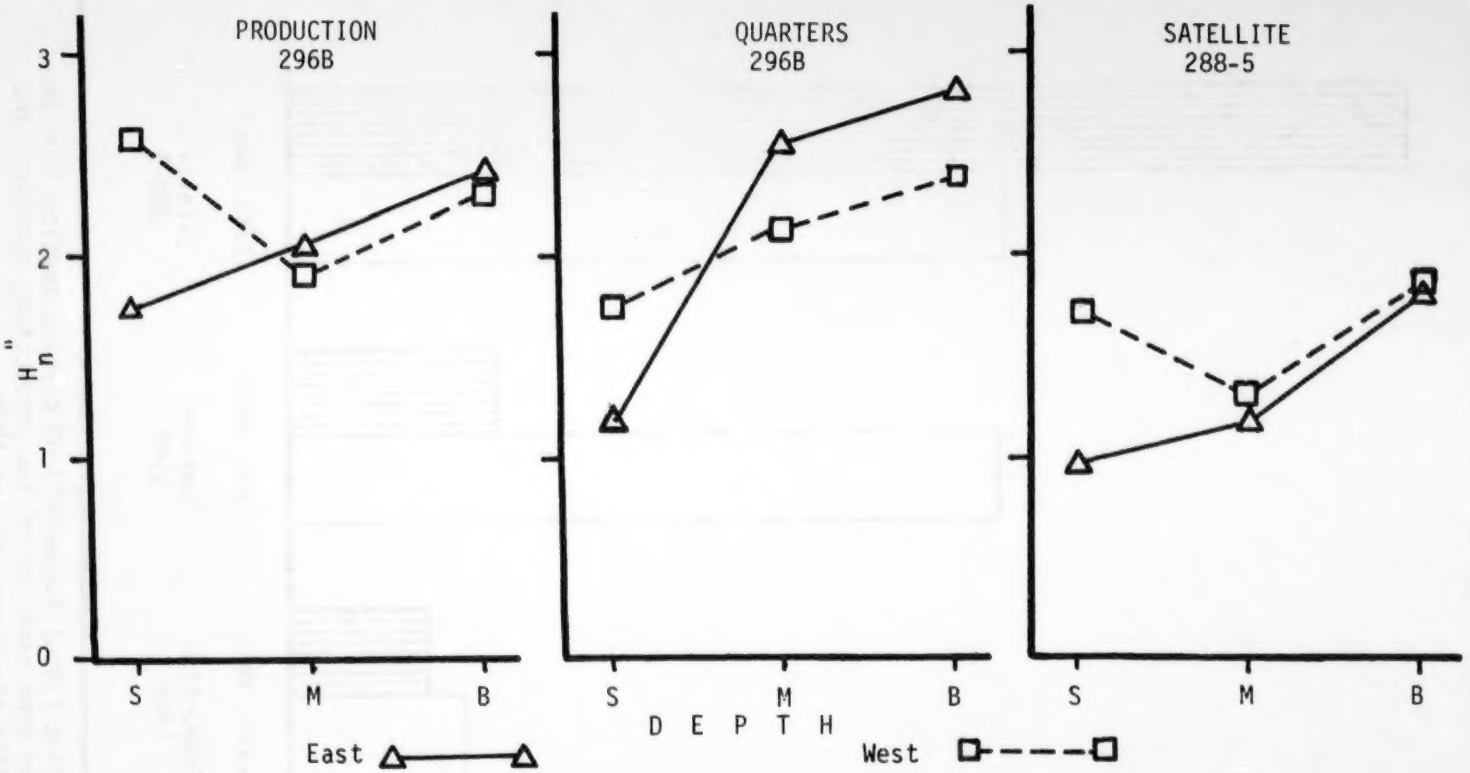


Fig. 18. Species diversity (H_n), based on numbers of cryptic species from jar samples, winter 1978.

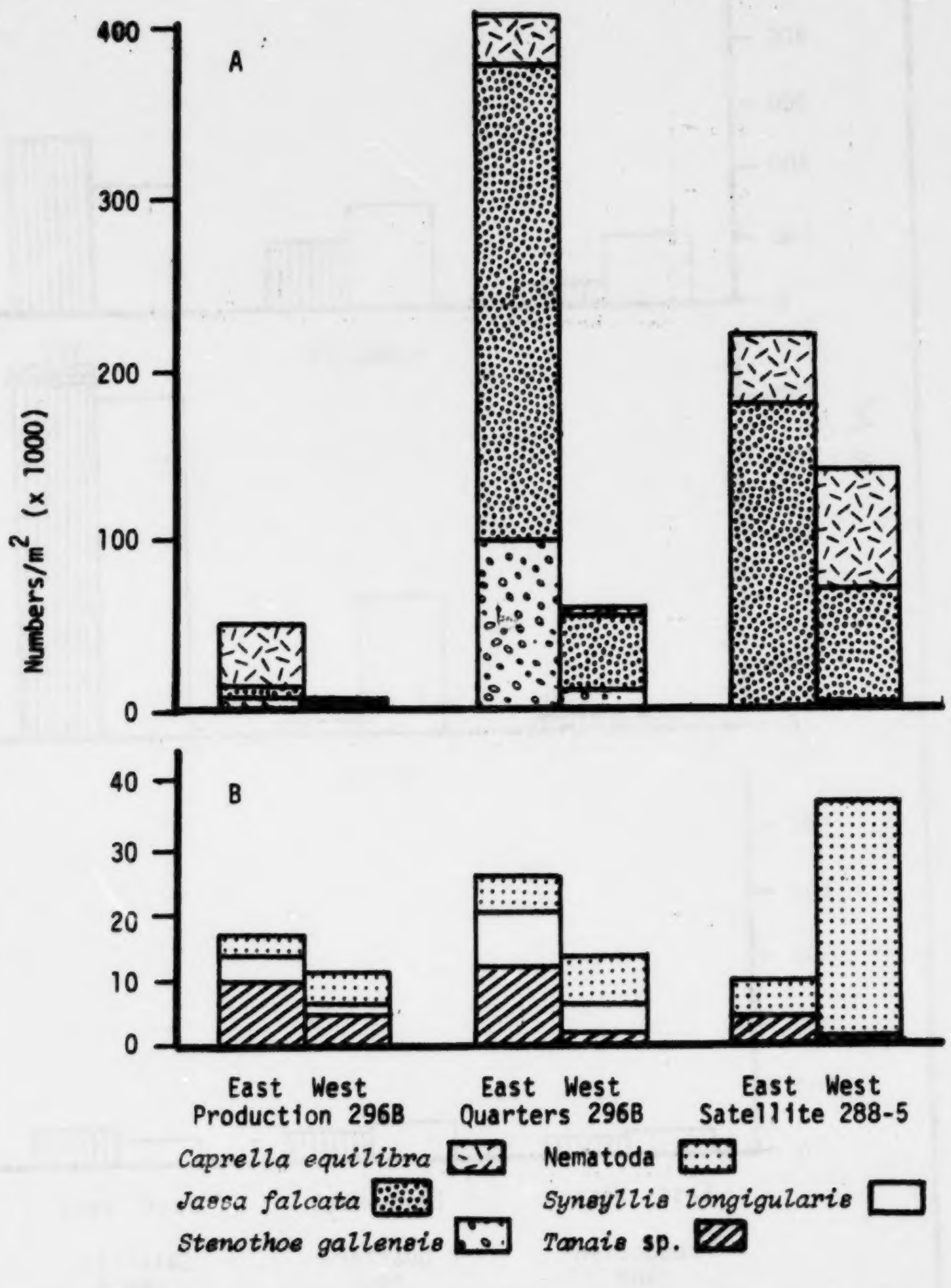


Fig. 19. Dominant taxa (numbers/m^2) at the surface stations from jar samples, winter 1978.

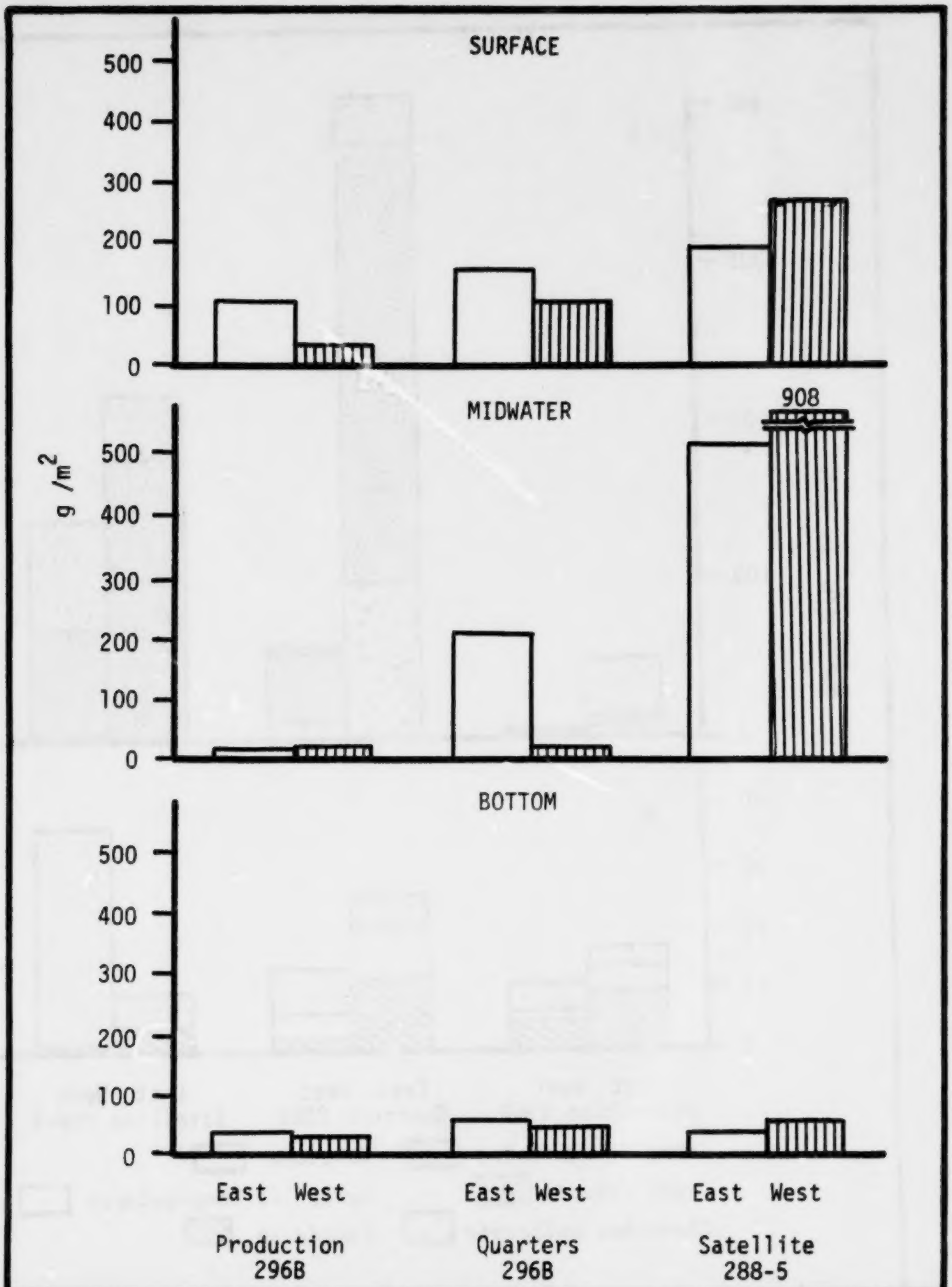


Fig. 20. Total biomass (g/m^2) of cryptic species from jar samples, winter 1978.

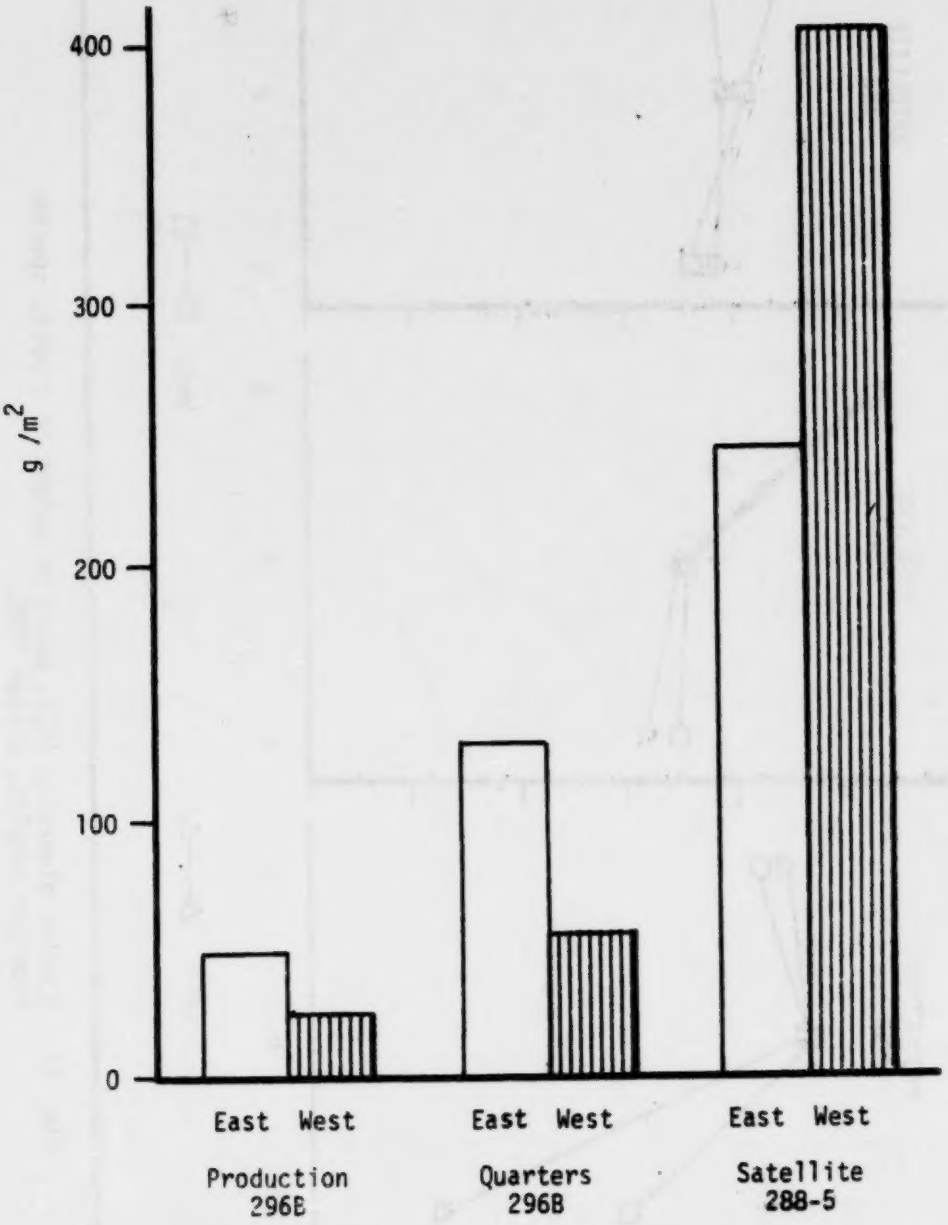


Fig. 21. Total biomass (g/m^2) of the cryptic species from jar samples from each leg of production, quarters, and satellite platforms, winter 1978.

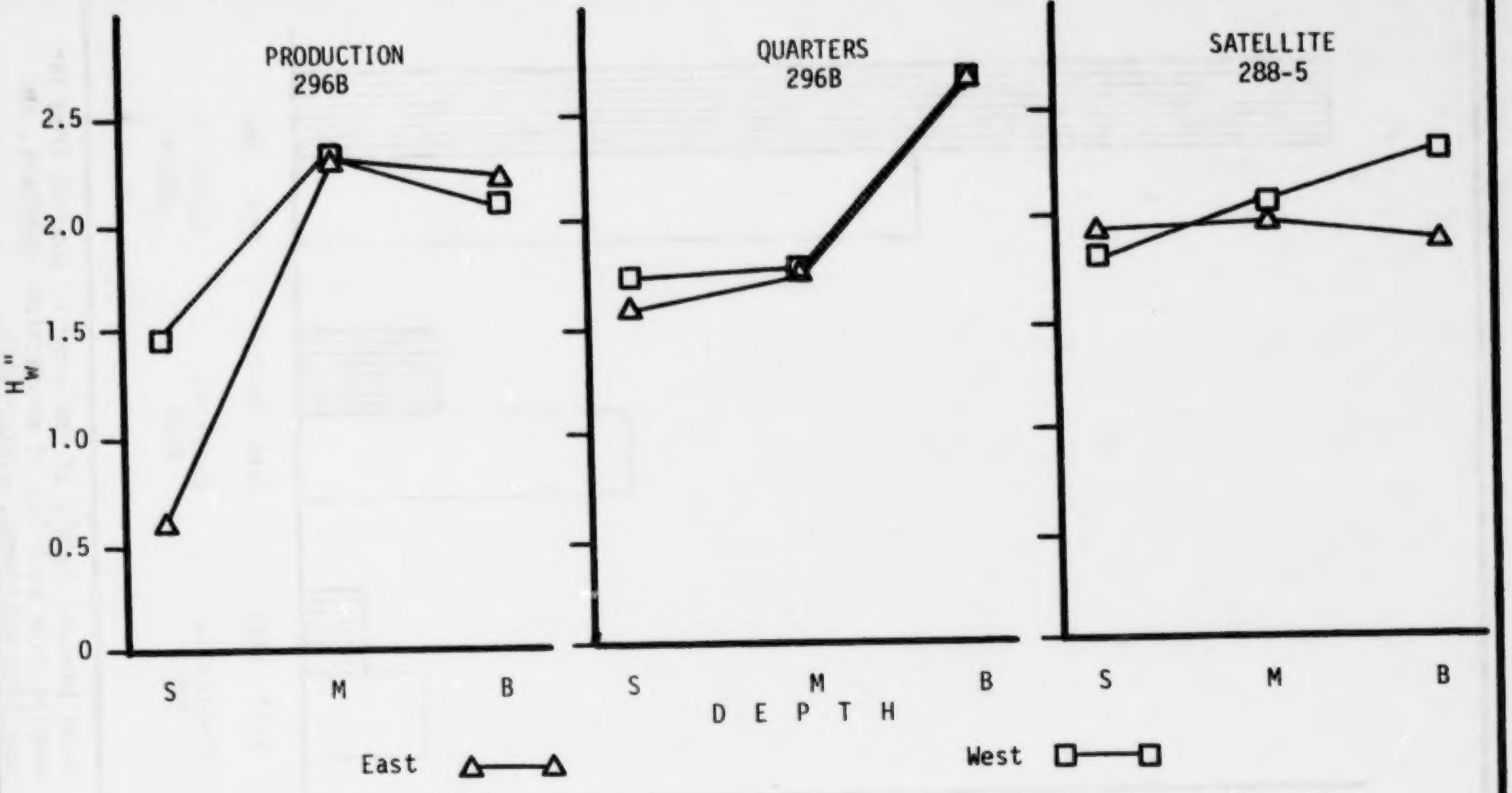


Fig. 22. Species diversity (H_W''), based on weight of cryptic species from jar samples, winter 1978.

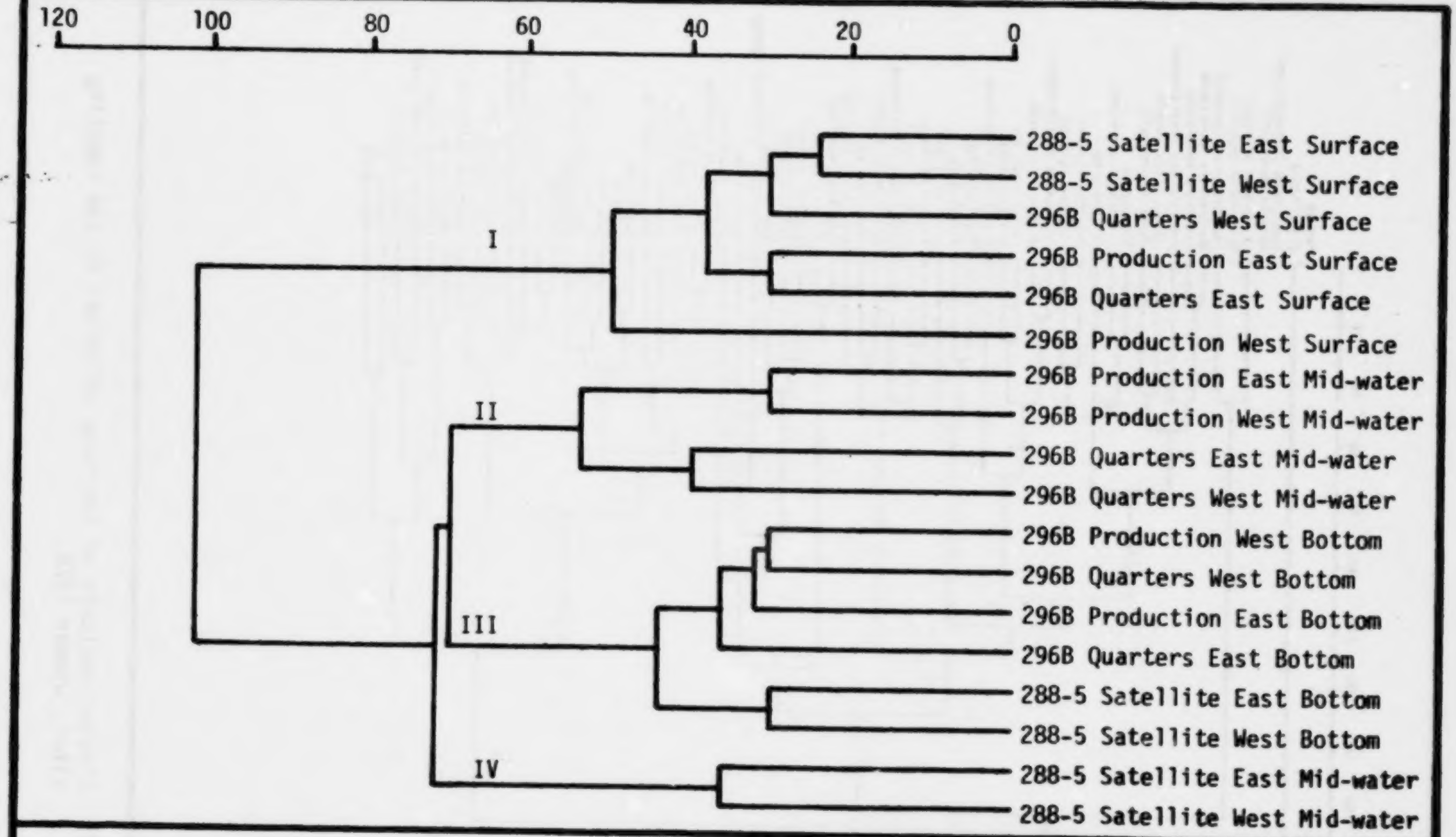


Fig. 23. Cluster analysis of the locations of sample collections, winter 1978.

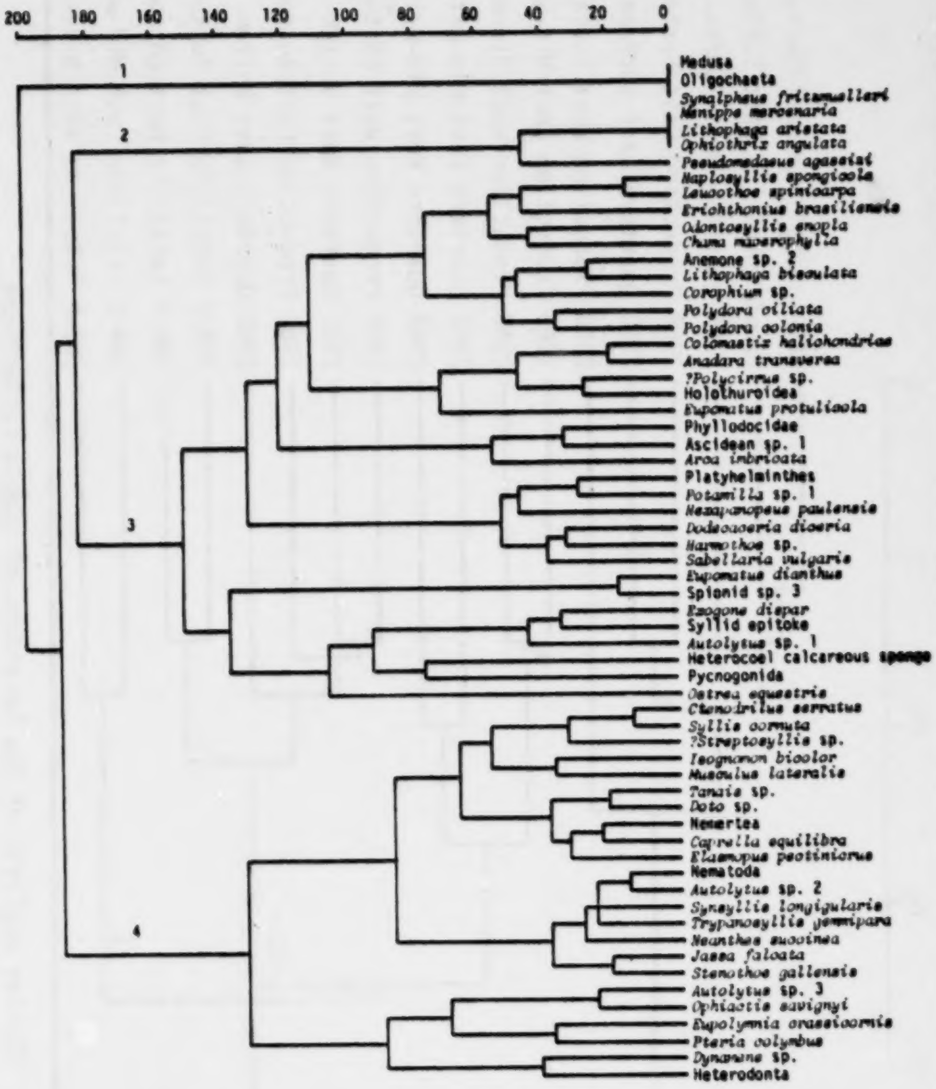


Fig. 24. Cluster analysis of the taxa collected at the sampling sites, winter 1978.

	288-5 East Surface	288-5 Satellite West Surface	296B Quarters West Surface	296B Production East Surface	296B Quarters East Surface	296B Production West Surface	296B Production East Mid-water	296B Production West Mid-water	296B Quarters East Mid-water	296B Quarters West Mid-water	296B Production West Bottom	296B Quarters West Bottom	296B Production East Bottom	296B Quarters East Bottom	288-5 Satellite East Bottom	288-5 Satellite West Bottom	288-5 Satellite East Mid-water	288-5 West Mid-water
Medusa									●									
Oligochaeta									●									
Synalpheus fritzmuelleri									●									
Menippe mercenaria																		●
Lithophaga aristata																		●
Ophiothrix angulata																		●
Pseudomedaeus agassizi												●						●
Haplosyllis spongicola						●	●	●	●		●	●	●	●	●	●	●	●
Leucothoe spinicarpa							●	●	●		●	●	●	●	●	●		●
Erichthonius brasiliensis							●	●		●	●	●	●	●	●	●	●	●
Odontosyllis enopla						●						●	●	●				●
Chama macerophylla									●				●	●			●	●
Anemone sp. 2	●								●	●	●	●	●	●	●	●	●	●
Lithophaga bisculata	●	●	●		●	●			●	●	●	●	●	●		●	●	
Corophium sp.											●	●	●	●	●	●	●	
Polydora ciliata							●	●		●		●	●	●	●	●	●	
Polydora colonia							●	●	●	●	●			●	●	●	●	
Colomastix halichondriae											●	●		●		●		
Anadara transversa											●	●		●				
?*Polycirrus* sp.												●	●	●		●		
Holothuroidea									●			●	●	●				
Eupomatus protulicola												●						
Phyllodocidae											●		●					
Ascidean sp. 1											●	●	●		●	●		
Arca imbricata													●					
Platyhelminthes													●			●		
Potamilla sp. 1													●	●	●	●		
Hexapanopeus paulensis														●		●		
Dodecaceria diceria											●					●		
Harmothoe sp.																●		
Sabellaria vulgaris												●				●		
Eupomatus dianthus							●							●				
Spionid sp. 3														●				
Exogone dispar		●				●			●	●		●						
Syllid epitoke		●			●	●						●						
Autolytus sp. 1					●	●		●	●									
Heterocoel calcareous sponge				●				●				●						
Pycnogonida				●	●													
Ostrea equestris										●								
Ctenodrilus serratus	●	●	●	●		●												
Syllis cornuta	●	●	●	●		●												
?*Streptosyllis* sp.		●	●			●												
Isognomon bicolor	●	●	●		●	●			●	●								●
Musculus lateralis		●	●			●			●	●	●	●					●	●
Tanais sp.	●	●	●	●	●	●	●		●									●
Doto sp.	●	●	●	●	●	●												
Nemertea	●	●	●	●	●	●			●		●		●				●	●
Caprella equilibra	●	●	●	●	●	●					●	●	●	●	●		●	●
Elasmopus pectinicrus	●	●	●	●	●													●
Nematoda	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●
Autolytus sp. 2	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●
Synsyllis longigularis			●	●	●	●	●	●	●	●	●	●	●	●	●	●		●
Trypanosyllis gemmipara	●	●	●		●		●	●	●	●	●	●	●	●	●	●	●	●
Neanthes succinea	●	●	●		●	●	●	●	●			●		●		●	●	●
Jassa falcata	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Stenothoe gallensis		●	●	●	●		●		●	●	●	●	●	●	●	●	●	●
Autolytus sp. 3		●															●	●
Ophiactis savignyi	●	●					●				●			●		●	●	●
Eupolymnia crassicornis																	●	
Pteria colymbus	●																●	
Dynamene sp.	●	●																
Heterodonta	●	●							●					●				

Fig. 25. Two-way table illustrating the relationship between the taxa and the locations of sample collections, winter 1978.

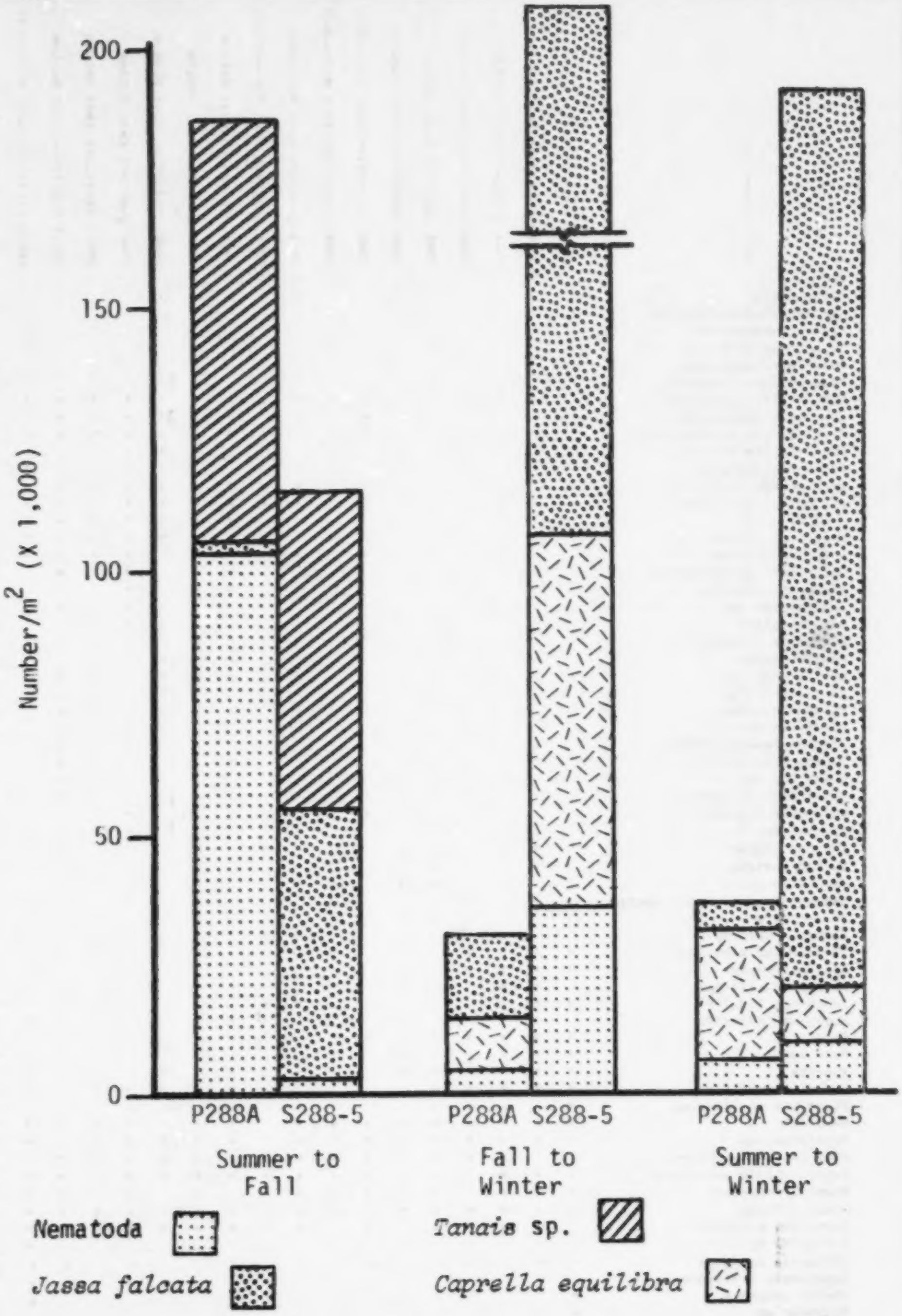


Fig. 26. Dominant taxa (numbers/m^2) from jar samples in summer to fall, fall to winter, and summer to winter recolonization periods at production platform 288A and satellite jacket 288-5.

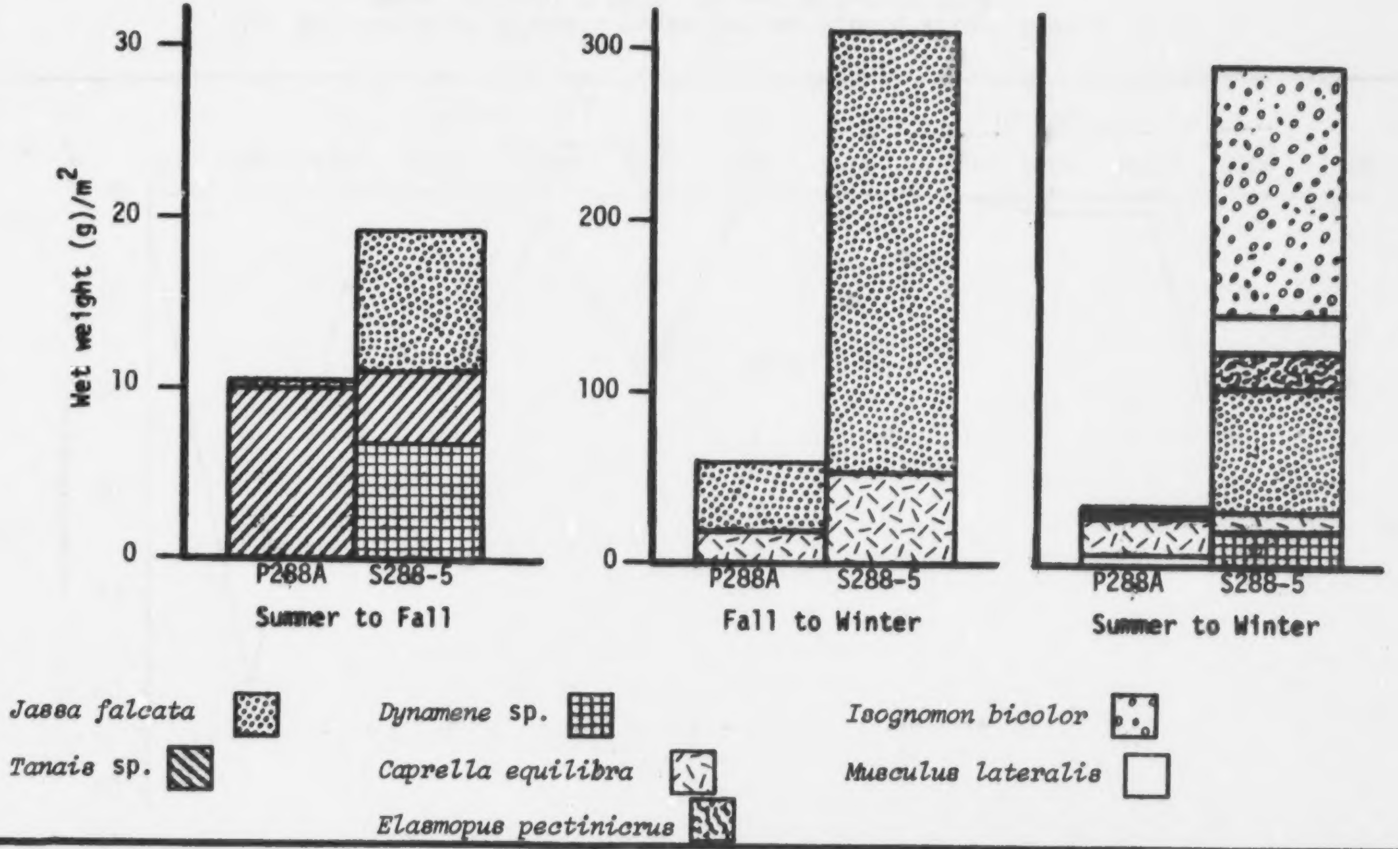


Fig. 27. Dominant taxa (g/m^2) from jar samples in summer to fall, fall to winter, and summer to winter recolonization periods at production platform 288A and satellite jacket 288-5.

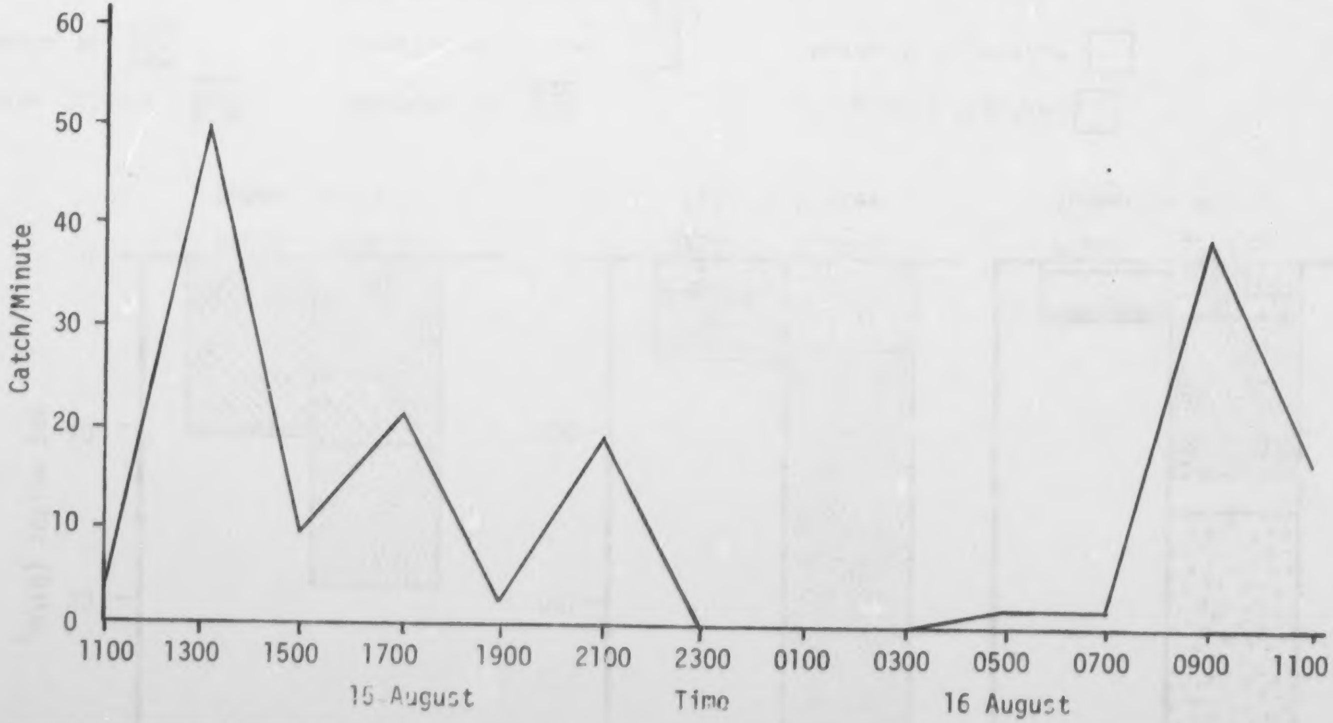
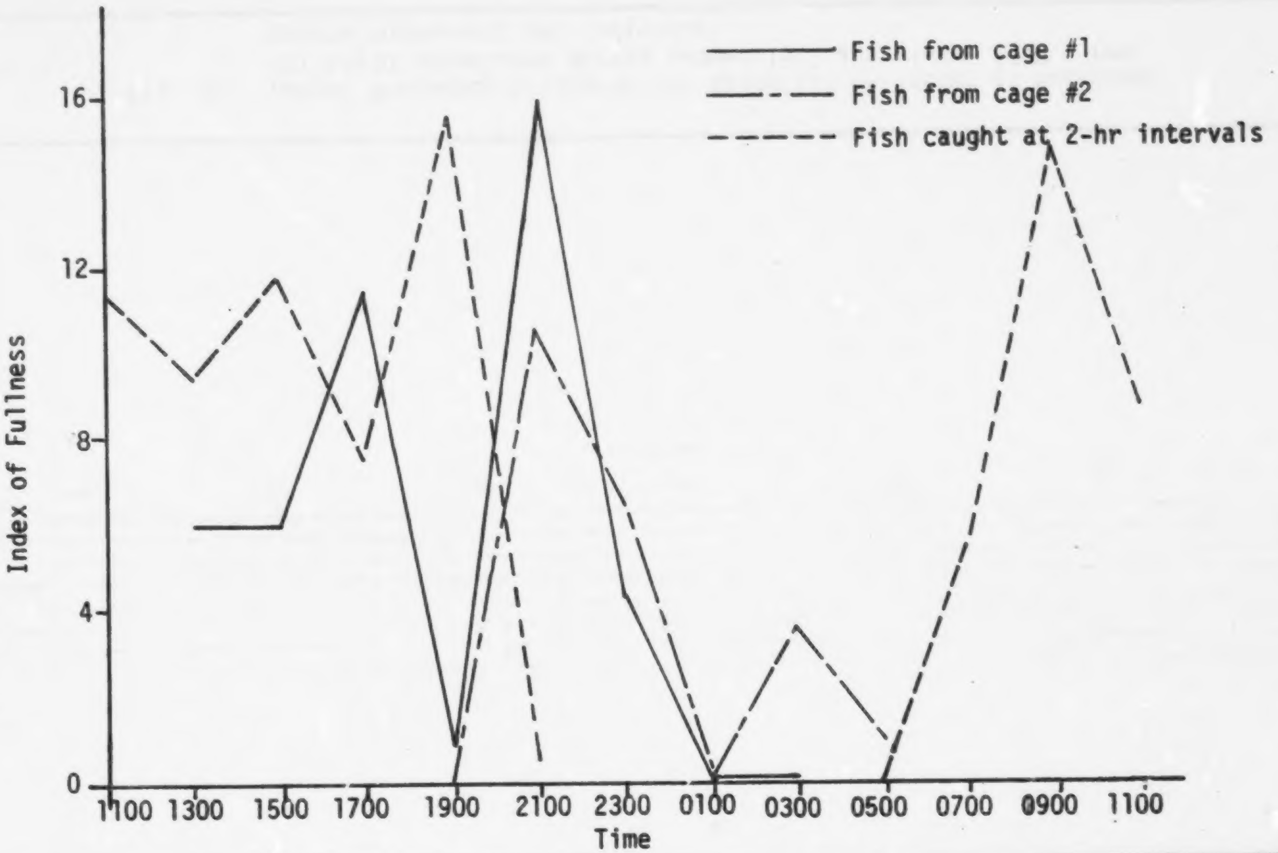


Fig. 28. Catch of Atlantic spadefish per minute effort over a 24-hr cycle at P 288A, 15 and 16 August 1977.



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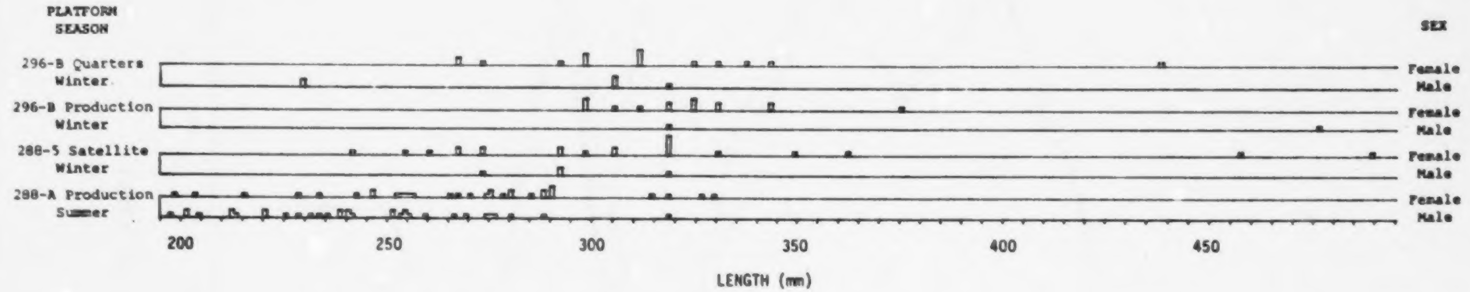

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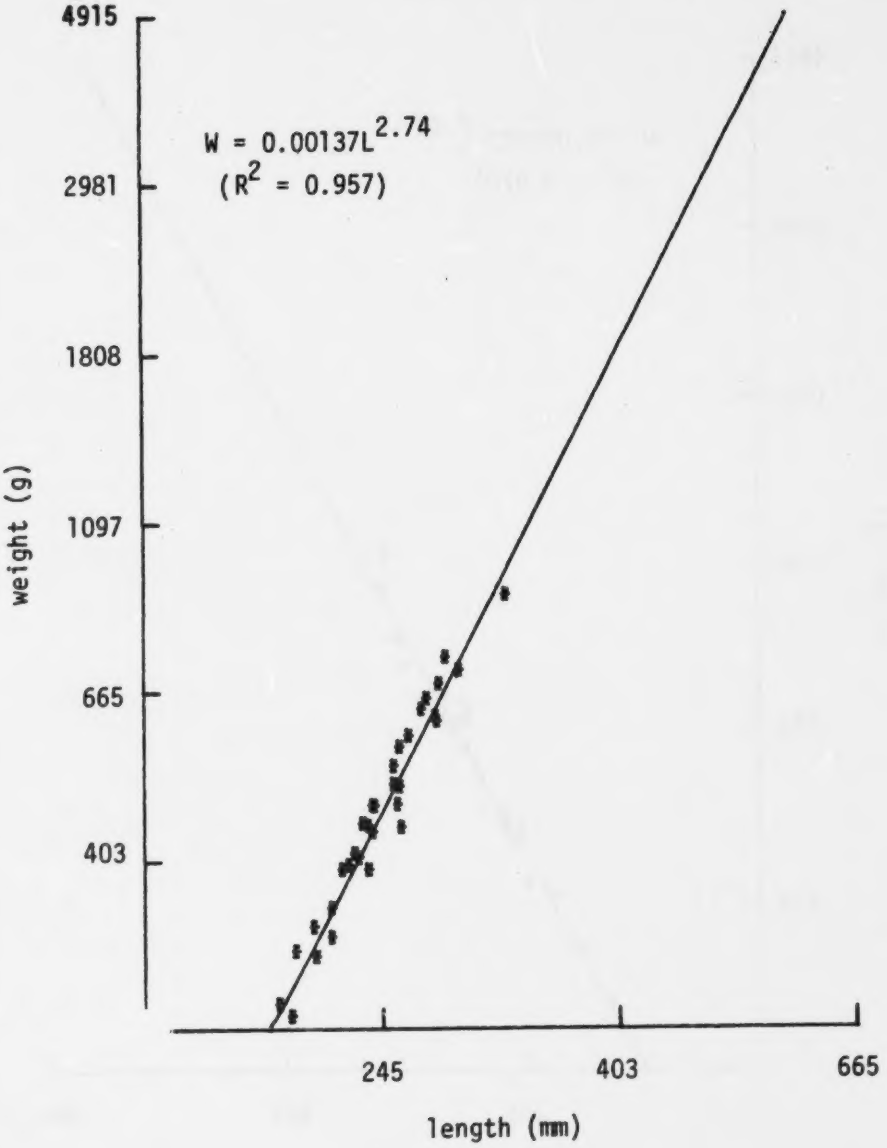

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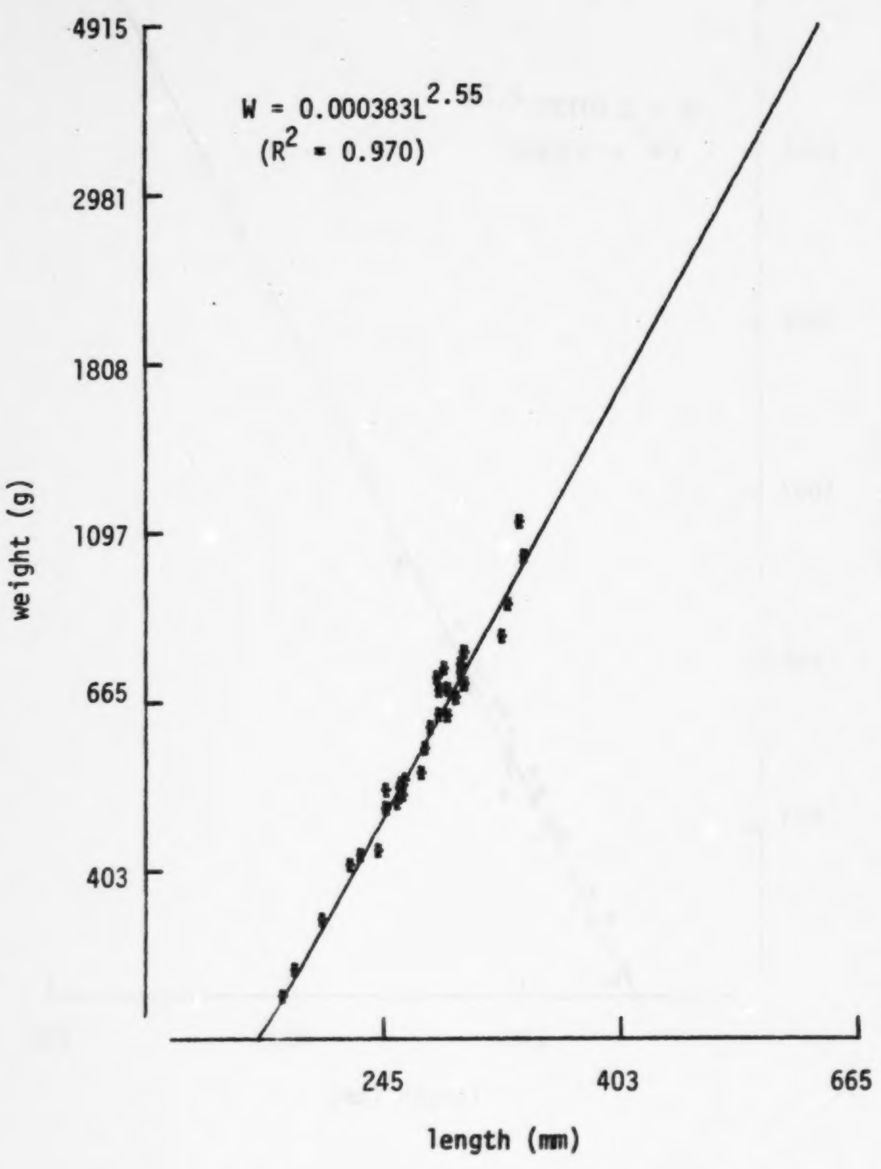
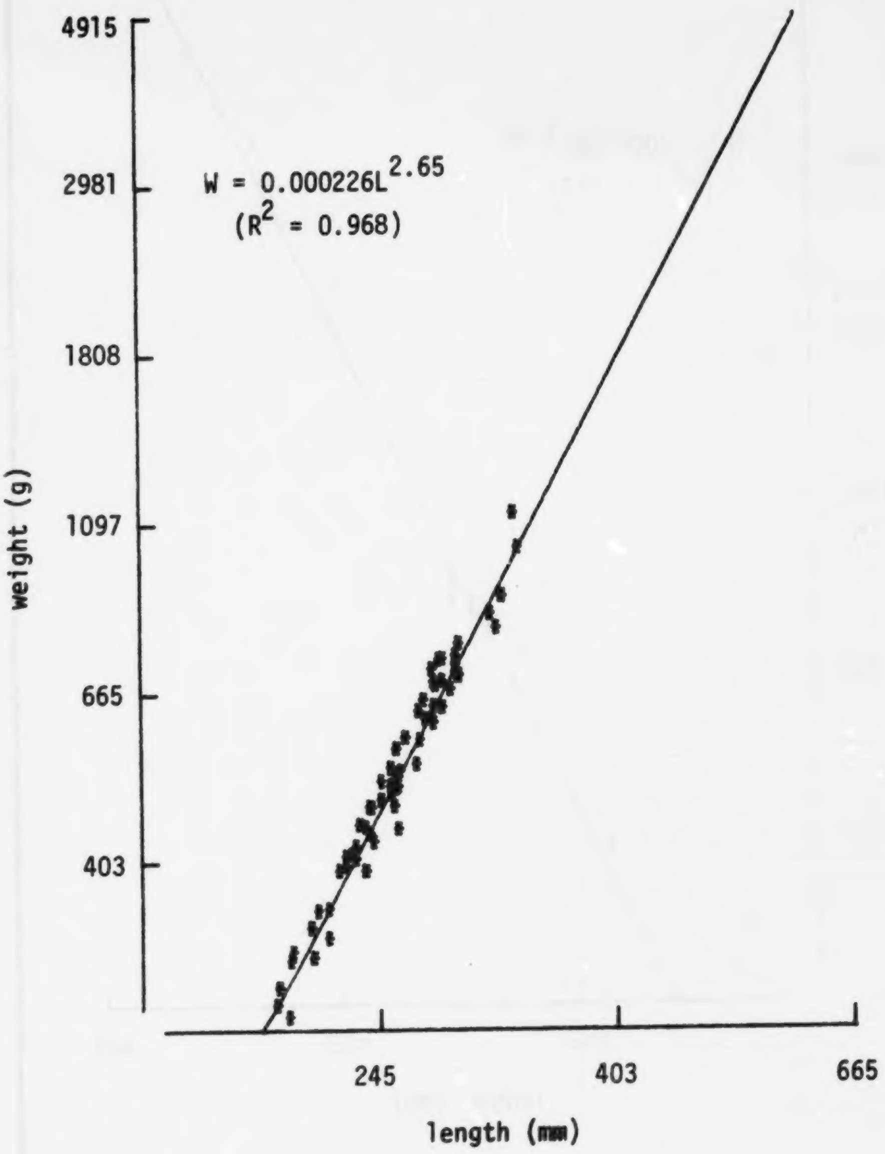


Fig. 32 . Length (mm) - weight (g) relationship for female spadefish collected during summer 1977 at Production Platform 288A. Note logarithmic progressions on both axes.



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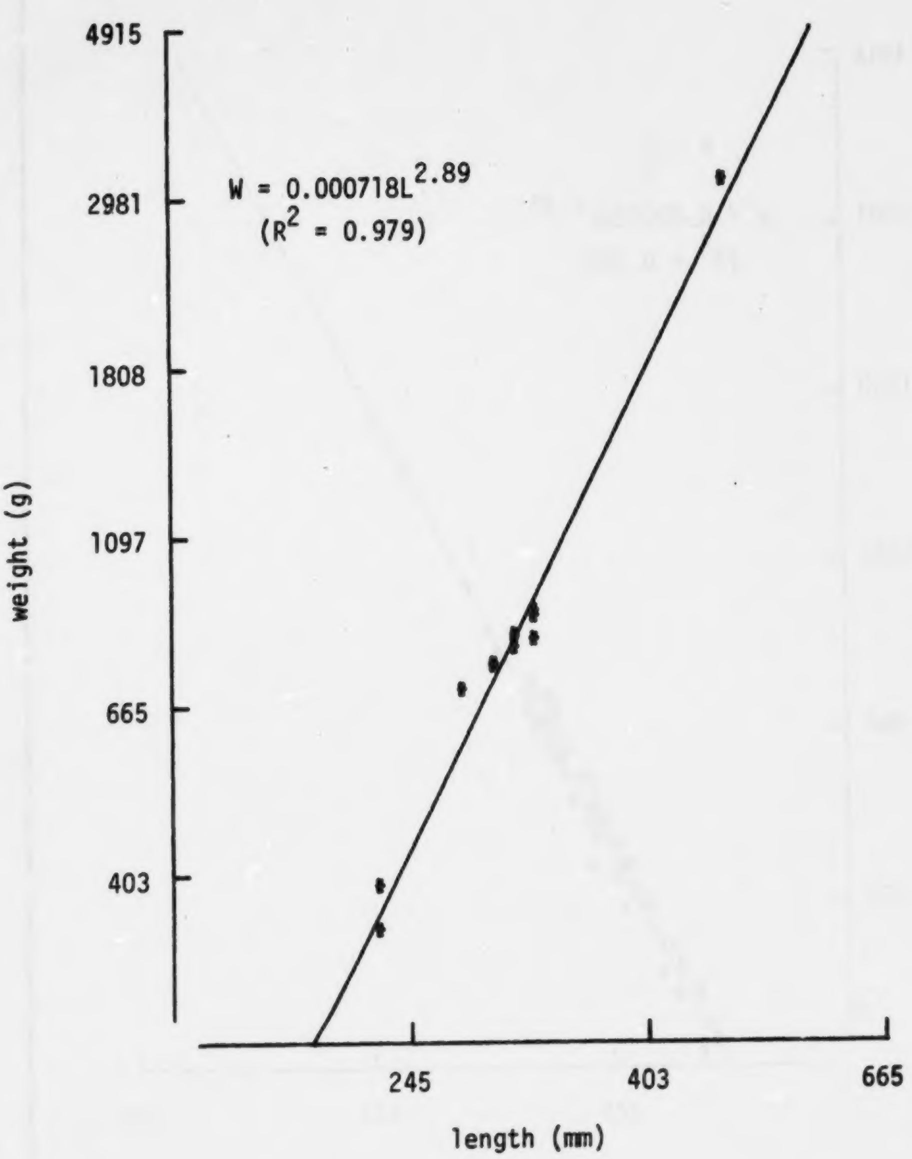

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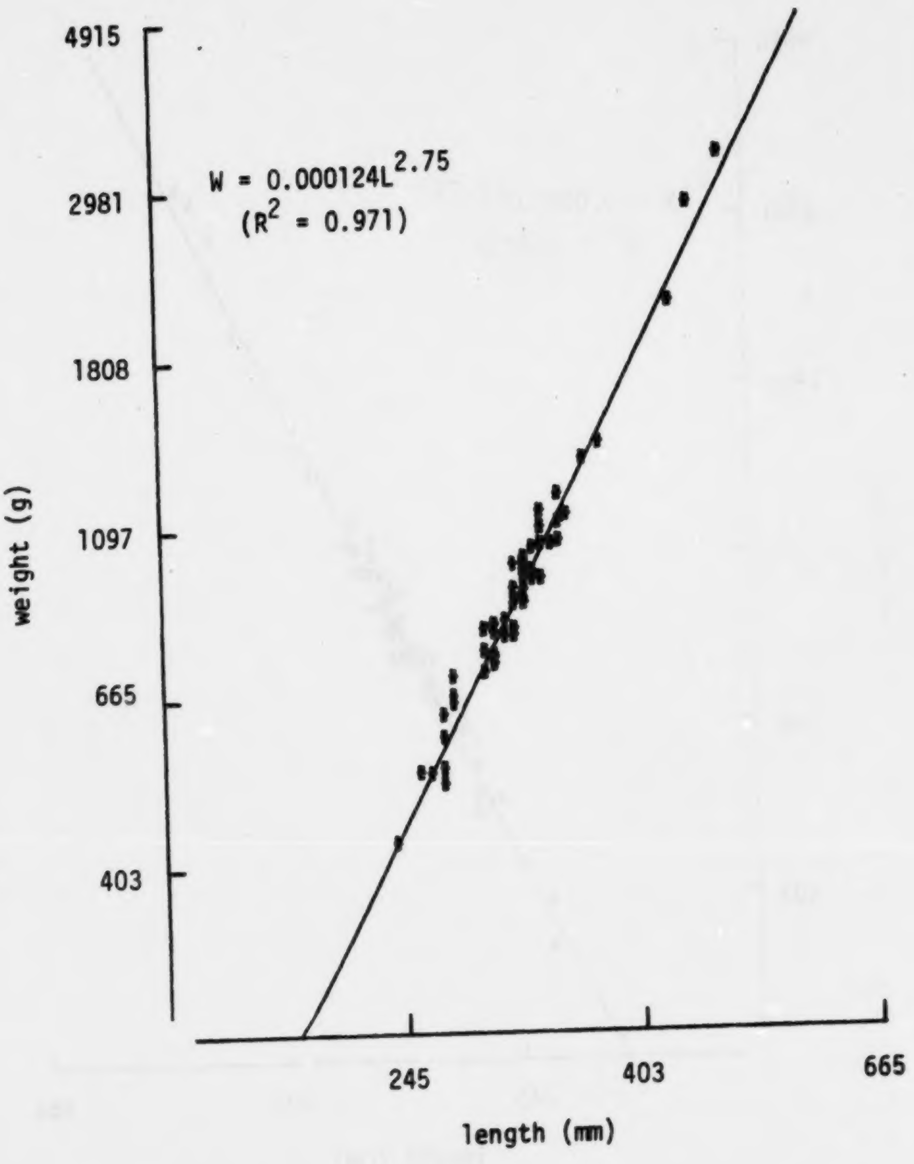

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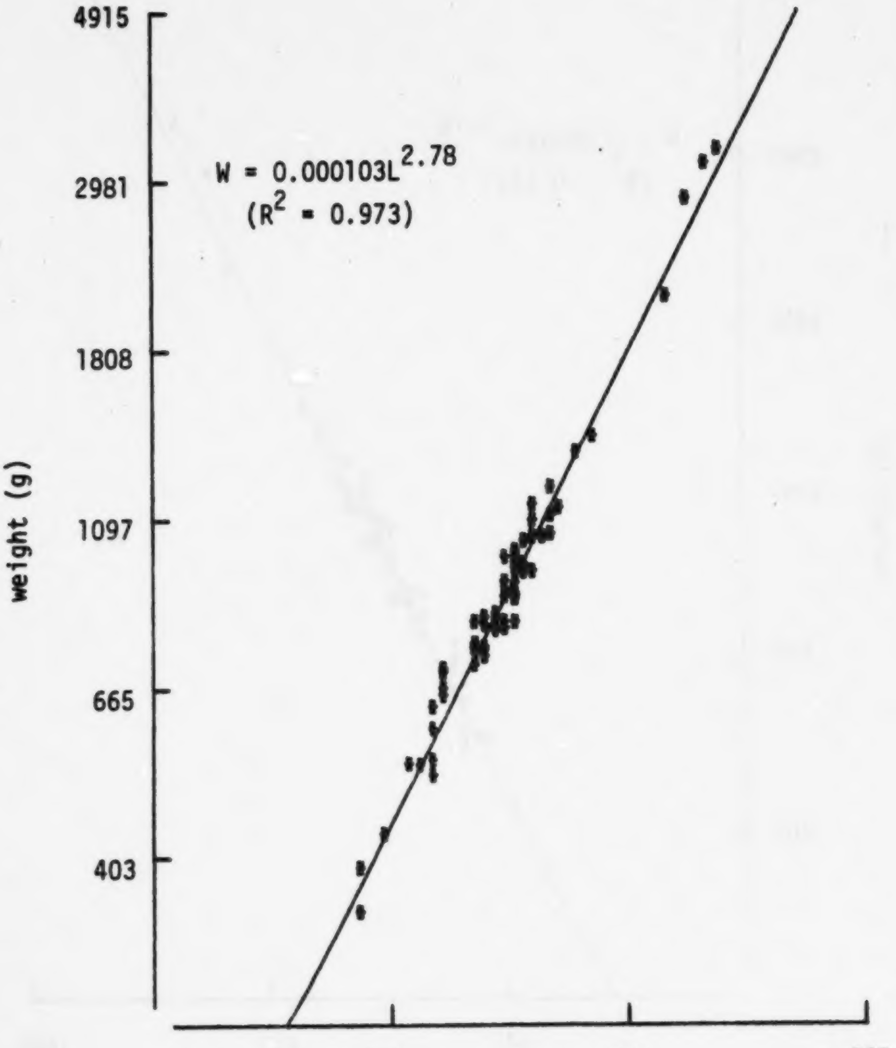

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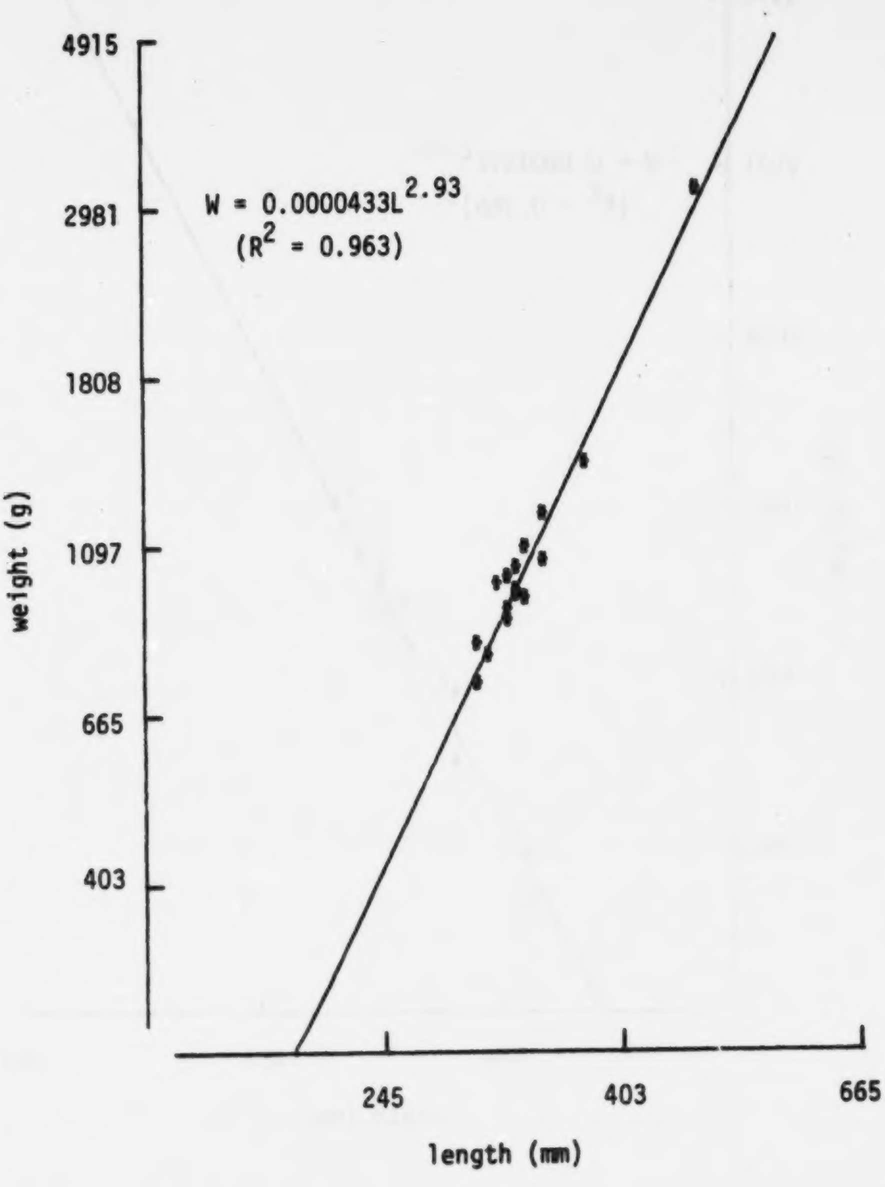

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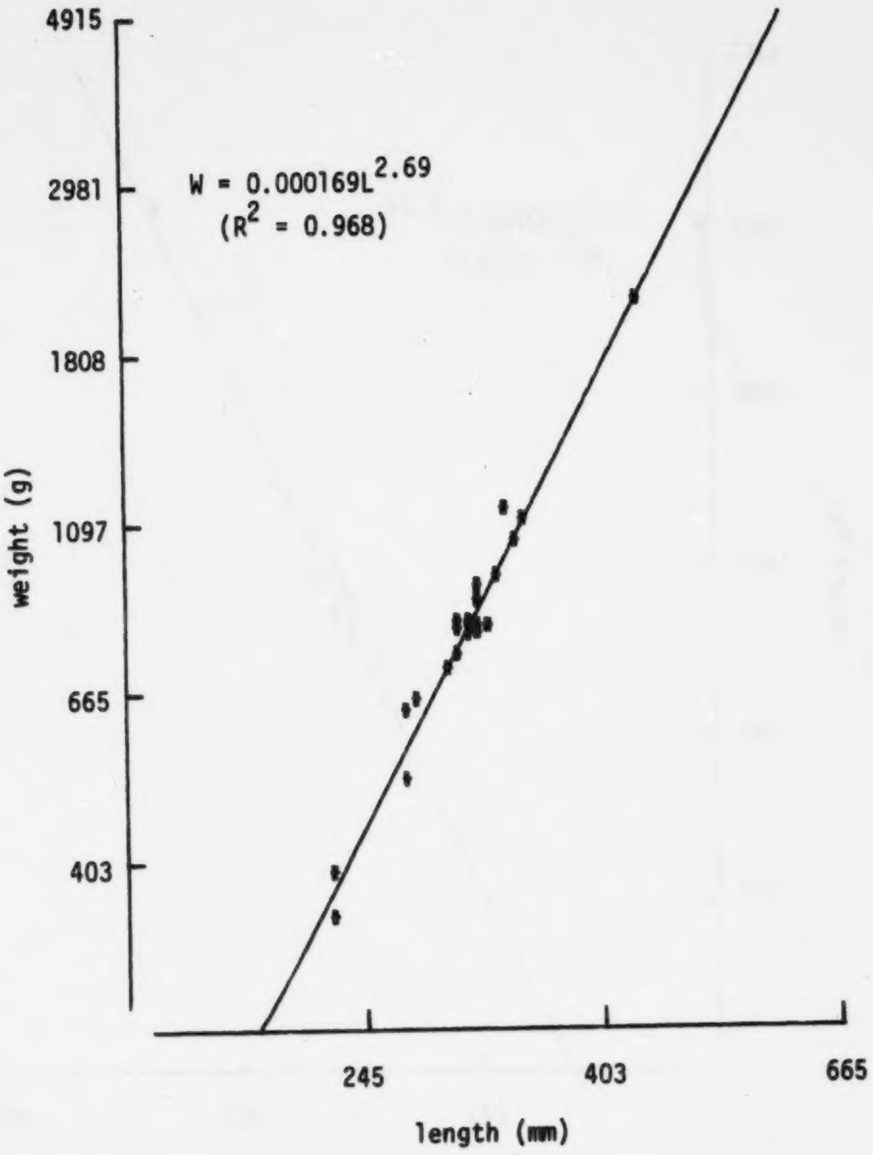

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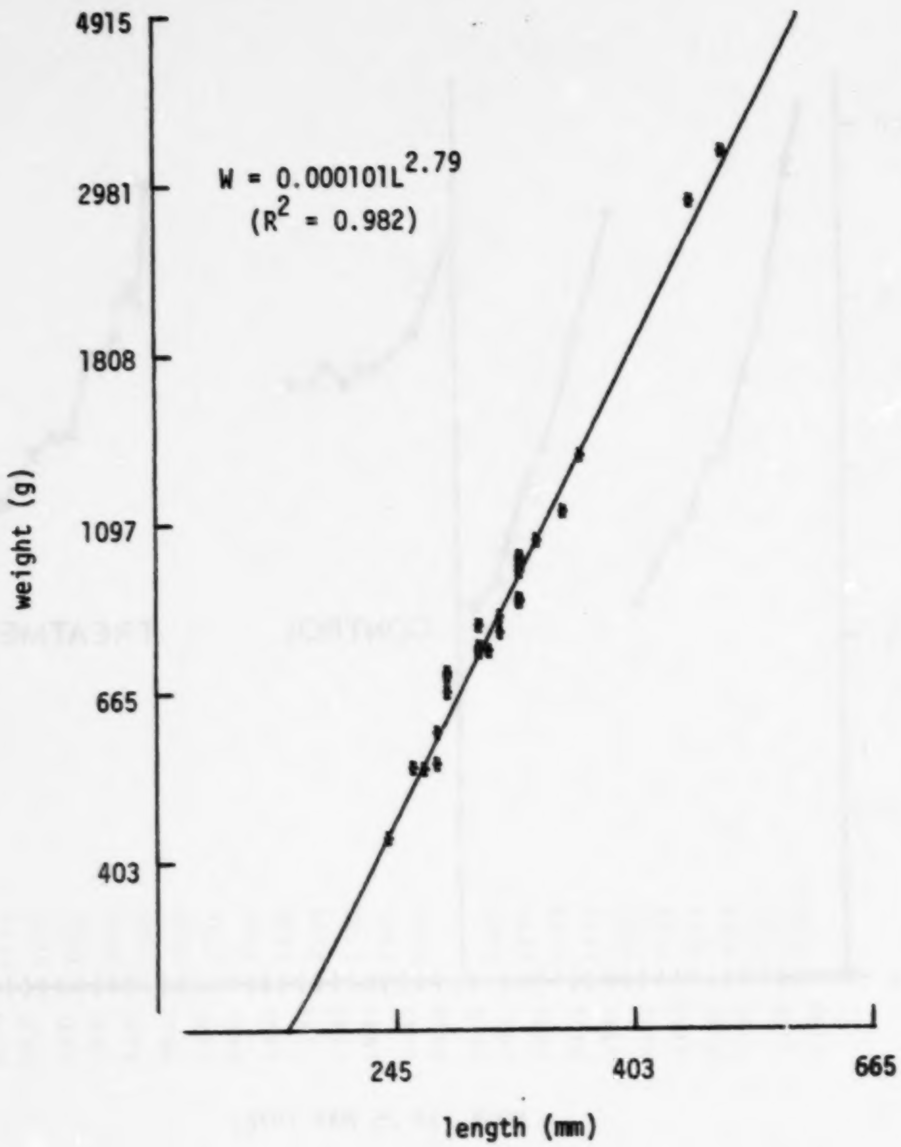

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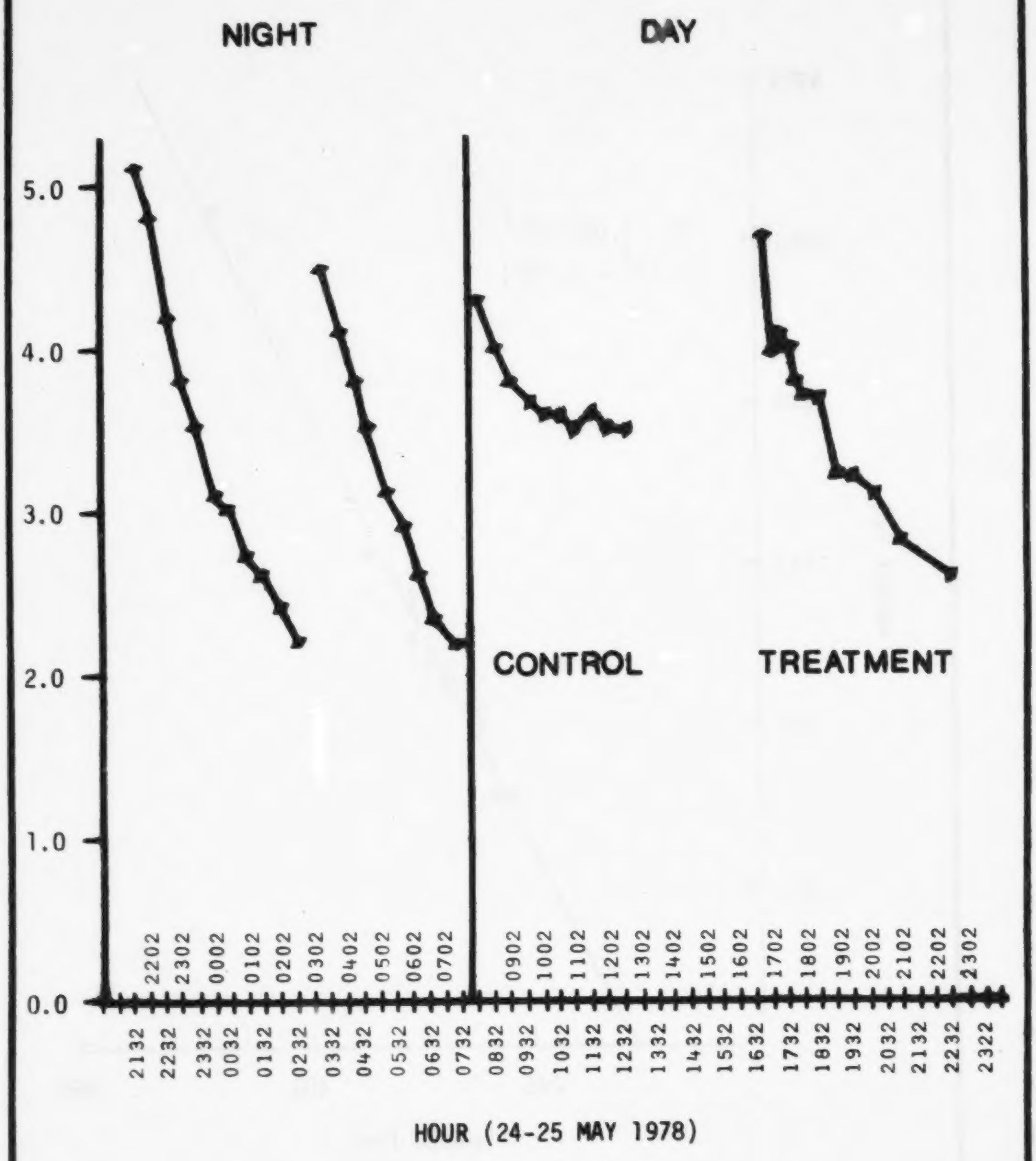

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SIMULATION MODELING OF BIOLOGICAL COMMUNITIES ASSOCIATED WITH A PRODUCTION PLATFORM IN THE BUCCANEER OIL AND GAS FIELD

A Draft Final Report for Work Unit 2.5.1
Ecosystem Modeling

by

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ABSTRACT

A production platform community of the Buccaneer Oil Field was modeled. The model consists of ten compartments and is represented mathematically as a set of linear, donor-controlled equations. Units were wet-weight biomass. A purpose of the chosen formulation was to test whether or not community dynamics could be explained in terms of resource limitations.

As parameterized, the equations provided a stable but sensitive solution for steady state conditions. Total system throughflow was predicted to be 576,485 kg/yr of which 483,109 kg/yr represented cycled throughflow. The average flow was estimated to cycle through 26.7 compartments before leaving the system. The cycling index of the model was 0.84 and similar to a cycling index (0.78) for a 14-compartment salt marsh model. Flow analysis indicated barnacles, sheepshead, spadefish, and suspended particulate material should serve as the best indicators as to whether or not hydrocarbons are being bioaccumulated in the system.

The linear, donor-controlled formulation provided a reasonable simulation of the seasonal dynamics of the fouling community flora (X_1) but not the other compartments (X_2-X_{10}). A realistic and stable simulation for one of these compartments (X_2, fouling fauna) for which data were available was produced by relaxing donor dependencies. We recommend that each of the submodels be similarly adjusted with the steady state version revised to reflect the resulting changes.

Based upon this first attempt to model the communities associated with an offshore production platform, it was concluded that the system is as it is modeled, i.e., particulate based and characterized by both (1) a high cycling efficiency and (2) high exchange of materials with the environment. In these respects, the production platform community resembles estuarine and natural reef systems.

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SIMULATION MODELING OF BIOLOGICAL COMMUNITIES ASSOCIATED WITH A PRODUCTION PLATFORM IN THE BUCCANEER OIL AND GAS FIELD

INTRODUCTION

The goal or purpose of this work unit was to develop a mathematical simulation which would characterize the marine ecosystem of the Buccaneer Field (BOF) area. Emphasis was to be placed upon biomass flows and the effects of platform discharges on these flows. The specific tasks or phases of the project were as follows.

1. Organization of existing information describing both the nature and history of BOF operations and biological systems associated with artificial reefs, particularly oil field structures, in the northern Gulf of Mexico.
2. Development of a conceptual model of the system which would describe current concepts of "normal" system behavior with a view toward delineating changes in that behavior related to oil and gas production activities.
3. Development of a reasonably detailed, descriptive mathematical simulation based upon the conceptual model modified as necessary by the results of current and ongoing research.
4. Provision of results of flow analysis of the model to identify major material flow pathways and accumulation points of contaminants in the system.
5. Provision of simulations defining sensitivity of the system to changes in the baseline values and functional relationships that were assigned to important processes, particularly those processes likely, or demonstrated, to be impacted by production activities.

Additional objectives of this task were to identify information or data which were lacking but critical to our understanding of the system, and to assist with program management. Data gaps were generally identified in the performance of phases 1-3 above, and modeling-management workshops were used to assist project management.

Preliminary descriptions of the BOF history and production activities, coupled with an ecosystem synopsis emphasizing artificial reef communities for the northern Gulf of Mexico, were provided by Gallaway *et al.* (1976). Results of this year's investigations and ongoing literature review have provided additional background information which is summarized below.

Developmental History of the Buccaneer Oil Field

The Shell Oil Company conducted initial seismic reflection surveys of the BOF in Federal Block 288 from 1953 through 1959. Based upon the results of this survey and regional geological studies, Shell acquired some 43,000 acres at the Federal lease sale in February 1960 and proceeded with the drilling of a discovery well (288 No. 1). This well reached a total depth of 16,088 ft in November 1960, but mechanical difficulties caused it to be abandoned and no tests were obtained on the potential pay sands.

During 1961 and 1962, additional seismic surveys were performed in Block 288 to better assess the size, shape, and complexity of the structural trap. In October 1963, another well (288 No. 2) was drilled at a location approximately 1 mi east of 288-1. This test well led to a multi-well delineation program and within a year, 21 additional wells were drilled, 12 of which were cased and completed from 4-pile satellite jackets.

The delineation program indicated that the field reserves were primarily gas and that those reserves could be most economically developed from two drilling-production platforms. The "A" platform, designated in this report as 288-A, was installed in September 1964 and 15 wells were drilled from the structure during the period of January-August 1965. Platform "B", designated herein as 296-B, was placed down in May 1965, and 15 development wells were drilled from it during October 1965 to July 1966.

As the field developed, an onshore gasoline plant was constructed near Freeport, Texas, and the plant was connected to the field (Platform 288-A) by a 20-in diameter flowline some 43 statute miles in length. Upon completion of platform 288-A wells, gas sales commenced on 1 January 1966 at the contract rate of 100 MMCF/day (1×10^8 ft^3 day^{-1}) of residue. This was increased in January 1967 to 175 MMCF/day (17.5×10^7 ft^3 day^{-1}) as platform 296-B began production.

Additional wells were drilled in the field between 1966 and 1971 for the purpose of oil rim development, for geopressured gas and oil, and for untested fault blocks located by seismic reviews. Four wells in those categories have been drilled in Block 289, which was purchased at the May 1968 lease sale. Through June 1971, 81 wells had been drilled in the Block 288 field; of these, 56 were completed and the remainder were plugged. Currently there are 34 active well zones, including 31 gas completions and 3 oil completions. Both production platforms and 6 of the 13 satellite jackets are active. The total fluid stream to the production platforms is approximately 1000 bbl/day from which about 65 MMCF of gas are extracted. The fluid typically contains about 600 bbl produced water and about 400 bbl of crude and condensate. Shell's current lease comprises portions of the Federal Blocks 288, 289, 295, 296, and 322 for a total of 20,070 acres in Federal Block 288 unit. Not all of the 81 wells that had been drilled in the Block 288 field through June 1971 were associated with structures that are presently sited in the oil field. For example, the first discovery well, 288-1, was drilled approximately 1 mi west of well 288-A. No structure presently marks this site. Additionally, a well was drilled and jacketed in Block 296 (well 296-5) but has since been plugged, dismantled, and the site swept clean by nets.

Drilling Activities

Drilling in the Buccaneer Field was initially accomplished using submersible or semi-submersible mobile drilling rigs. These rigs set a caisson (casing) which is telescoped downward by adding pipe successively smaller in diameter as the well is drilled deeper and/or outward. When the well is completed, a "christmas tree" assembly is added to the caisson and a jacket or platform is towed from shore and fitted around the caisson structure. Appropriate valves, pipelines, etc., are then attached to the assembly. The well jacket design enables attachment of drilling rigs such that additional wells can be drilled from the structure.

Generally, in a drilling operation the muds are recycled as much as possible. Muds and cuttings are usually washed on a "shale shaker" or screen at the drilling rig to remove any free oil and muds from the cuttings before the cuttings are dumped overboard. The drain from the washing table leads to a separator vessel where the muds, including any free oil, are extracted as much as is economically feasible or practical, and the remaining water containing dissolved and suspended materials is discharged overboard.

The following inputs to the marine environment are usually associated with drilling activities.

1. Addition of solid materials to substrates in the vicinity of the drilling site in the form of drill cuttings and sand. Additional debris such as scrap metal, wire, tools, batteries, and drilling mud containers are sometimes lost overboard.
2. Discharge of seawater containing dissolved and suspended materials, the composition of which is a function of the drilling mud components. In the past, drilling muds have in many cases been oil-based and have contained components such as barium and sulfur-based compounds.

Structures and Associated Production Activities

Structures that remain in the Buccaneer Field are of five types: production platforms, quarters platforms, satellite well platforms, flare stacks, and pipelines. A total of 18 platforms has been constructed in the field: 2 production platforms, 2 quarters platforms, and 14 satellite platforms.

Satellite Platforms

There are currently 13 satellite wells or platforms located in the BOF, six of which are active. Each structure or well jacket consists of a small platform or deck (approximately 6 X 6 m) supported by 4 piles or legs which are appropriately braced. The well jacket is open on one side such that it can be fitted around a well caisson (Fig. 1). A boat landing is located on one side about 2 m above normal water level and is connected by stairway to the main deck. The christmas tree assembly (various valves and gauges) is on the main deck. The pipelines which connect the satellite well to a production platform run down the side of the structure to the bottom, and from there to the respective production platform. A stairway connects the main deck to a small helicopter landing above the main deck. Each platform is lighted and equipped with a foghorn which sounds at regular intervals.

The subsurface portion of each BOF satellite structure provides about 548 m^2 of hard-substrate habitat, none of which is influenced by discharges except during the drilling period. Oil and gas are neither stored nor processed at a satellite structure but are directly transported to a production platform. Collectively, satellite platforms in the BOF provide some 7,124 m^2 hard-substrate habitat. Some of these structures may be removed during the course of this study, whereas others may be used for additional drilling.

Production Platforms

The two production platforms in the BOF are large, complex structures (Fig. 2). The basic design of each platform is identical, but they differ in that a large gas compressor is located on the upper deck of Production Platform 296-B, whereas oil storage tanks are located on the upper deck of Production Platform 288-A. Each platform is supported by 12 legs and is designed for an array of 24 well casings located in the approximate center of the structure. Pipelines from satellite wells are located on one end of each structure and extend from the bottom up to the lower of the two top decks.

The separation process begins on the lower deck of each platform. The product (condensate) flows into high-pressure or first stage vessels which essentially separate the gas from oil and water. All of the gas produced from the field is compressed at Platform 296-B using air-cooled turbine compressors located on the upper deck. Once compressed, the gas is piped to Production Platform 288-A and thence to the Freeport facility.

The remaining oil and water flow to interstage, pressure-step-down vessels, located on the upper decks of the platforms. Here the pressure is further reduced to that of the atmosphere as the product flows into the next vessel or "gun barrel." The "gun barrels" serve as gravity separators, segregating the oil from the water. All of the oil produced and separated is piped to the large storage tanks located on the upper deck of Platform 288-A.

Produced water flows to "skim tank" vessels, also at atmospheric pressure, located on the lower decks. Any remaining petroleum products are separated there and are put back into the oil-stream flow. The remaining water is discharged overboard. All drains on the production platform, including those from "drip pans," "skid pans," and gutters, also flow into the skim tanks.

The BOF condensate differs from that in most oil and gas fields in that levels of microbial organisms which cause corrosion in the system necessitate the use of biocides. During the first part of this research year, 12 and 9 gallons of biocides per week were used on each of Production Platforms 288-A and 296-B, respectively. Biocide was injected into the system continuously at a rate of 1 gal per day supplemented by "shock treatment" injections into the gun barrel and skim tank vessels of each platform. More biocide was required at Production Platform 288-A (4 gal at gun barrel; 1 gal at skim tank) than at Production Platform 296-B (1 gal to each vessel). In addition to the biocide, a detergent (SURFATRON DQ-44, a cocoalkanolamine), was added to enhance the toxic properties of the chemicals to the target microorganisms.

Two biocides were used and alternated to prevent the bacteria from developing resistant strains. Initially the biocides used were BACTRON K-31 (pentane dialdehyde) and BACTRON K-14 (alkyl dimethyl chloride). The latter chemical was later replaced by a chemical of similar structure, BACTRON KM-7.

Seawater pumps with subsurface intakes are located on the lower decks of each production platform. Seawater is used to maintain the platform's fire-fighting systems and for the production of fresh water. The pumps are fitted with back-pressure valves such that excess seawater is discharged when desalination plants and fire fighting lines are at capacity and pressure, respectively.

We estimate that each of the production platforms provides some 3,800 m^2 of subsurface habitat. On each of the two production platforms, a produced water discharge pipe extends along a leg on the west side of the platform from the skim tank down to a point about 2 m above the water. The rate of the discharge varies depending upon the amount of production. On an average, some 95.4 m^3/day produced water is discharged.

Quarters Platforms

Quarters platforms contain in addition to kitchen, living and recreational quarters, a gas-fired electrical generator, a desalinization plant, and a sewage treatment plant. A helicopter landing pad is located on the upper deck. An upper and lower platform deck are each about 40 ft X 40 ft. All garbage except food scraps is compacted and transported to shore for disposal; food scraps are collected and dumped overboard. Initially, about a dozen persons resided in the field, with the work force supplemented as necessary. Due to activity in other areas and the decline in BOF production, the work force has been greatly reduced.

Water needs are normally met by the desalinization plant, although lines are present to take fresh water onto the platform from boats. The energy source for the Maximum Aquafresh Evaporators is hot water supplied in a closed system from the engine jacket water of the electrical generating plant. Seawater is boiled at a low temperature under vacuum to create vapor and the vapor is condensed to pure water. Raw seawater is pumped continuously through the fresh water condenser, with most of the seawater being discharged overboard. A certain quantity, however, is directed from the fresh water condenser outlet through an evaporator feed valve into the evaporator shell where it is boiled. Brine from this operation is continuously drawn off from the shell by the brine jet pump and also is discharged overboard.

The vapor produced by the boiling of seawater passes up through a monel mesh separator where any droplets of water or entrained particles are removed. Thus, only pure vapor enters the freshwater condenser section. This vapor passes over the tubes of the freshwater condenser where it is condensed by the action of cooler seawater flowing through the tubes. The resultant freshwater is collected in a trough and is pumped to the storage tank by the freshwater pump. The evaporator shell vacuum is maintained by evacuating the uncondensable gases from the shell with a vacuum jet pump. The plants are located on the upper decks and the storage tanks are located on the lower decks of the quarters platforms. The freshwater storage tanks have an overflow valve which discharges small amounts of freshwater overboard when filled to capacity.

Sewage treatment plants located on the lower decks of the quarters platforms utilize an activated sludge treatment process. Wastewater flows from an inlet pipe into a screening basket which retains rags, sticks, and other large objects that should not be allowed to enter the treatment plant. The wastewater then passes into the aeration compartment where it is mixed with activated sludge.

Blowers bubble air into the aeration compartment through air diffusers which are suspended from an air header. The air is compressed with an electric motor-driven blower mounted on the treatment system units. Air bubbled into the aeration compartment establishes mixing velocities suitable to keep the solids in suspension and to provide the amount of dissolved oxygen needed for efficient treatment. This water-solids mixture is called "mixed liquor." Mixed liquor in the aeration compartment flows into an energy absorption compartment through a submerged pipe. Flow entering the energy absorption compartment is first confined between two submerged baffles where the energy of the liquid is greatly reduced. This assures minimum turbulence in the clarifier. Low energy flow passes over and under the submerged baffles and through slots and into the clarifier.

Solids which are heavier than water settle to the clarifier bottom and are returned to the aeration compartment through a slot. Clear water near the surface of the clarifier passes over the outlet weir and is carried from the treatment system to a chlorine contact tank, and finally, the treated effluent is discharged overboard. Presumably, the effluent would contain residual chlorine.

The wastewater can contain some floatable material that can rise to the surface of the settling compartment energy absorption zone and clarifier. The treatment plants are equipped with a hydraulic skimming system for handling floating material. Floating material is returned to the aeration compartment through a specially designed skimmer trough. The skimmer trough is fitted with flow deflector plates on the aeration compartment side of the wall that separates the settling and aeration compartments. Circulating flow past the deflector plates sets up a suction or return flow in the skimmer trough.

Electricity for production and quarters platforms is generated on the quarters platforms using gas-fired electrical generating units. The units use a radiator-type cooling system. As indicated above, the engine jacket water is used as an energy source for the desalinization plant.

We did not have drawings from which to estimate the subsurface area of the quarters platforms. We estimate that the area provided is roughly equivalent to that provided by a satellite platform (about 550 m^2). Quarters platforms are slightly larger than satellite platforms but have fewer cross members and less bracing.

Flare Stacks

Each of the production platforms has an associated flare stack sited a short distance away from the platform. This is an emergency safety device and no discharges are normally associated with these simple structures. In an emergency, condensate is shunted to and discharged out the flare stacks. These discharges, although infrequent, are spectacular. Each flare stack provides less than 50 m^2 subsurface habitat.

Pipelines

Satellite wells and production platforms within the field are connected by submerged pipelines; all 10 in or greater in diameter are buried. A buried pipeline of 20 in diameter connects the field at Platform A to the onshore facility at Freeport.

Miscellaneous Activities

Transportation

Transportation to, from, and within the oil field is both by boat and helicopter. Large packages of freight brought to platforms are removed from boats by cranes located on the upper decks of the platforms. Solid materials (scrap metal, pipes, valves, tools, batteries, wire) are sometimes lost overboard near platforms either during offloading procedures , during routine servicing of the platforms or during storms. Depending on their value, these materials are either retrieved by divers or left on the bottom. It should be noted, however, that when a platform is removed, the site is swept clean by nets.

Sport Fishing and Diving

The Buccaneer Field is a focal point for offshore sport fishing and diving activity in the area. Sport fishing boats range in size from 16-ft long boats to large yachts and sailboats. Many of the craft that come to the area are only marginally seaworthy and are in various states of operating efficiency. Seldom can free oil and gasoline not be detected emanating from at least a few of the pleasure craft in the field. Fuel is sometimes inadvertently lost overboard during the course of field repairs on less seaworthy vessels. Bottles and paper are frequently thrown overboard from pleasure craft. Raw sewage and food wastes are commonly discharged overboard.

Commercial Fishing

The Buccaneer Field area was apparently a good shrimping ground before the field was established and has apparently remained so. One of the most significant activities of commercial fishing operations is the culling and subsequent return to the water of small demersal fishes and other organisms captured with shrimp in the trawls. These organisms provide an easily utilizable food source for pelagic predatory fish that would be less available with the absence of commercial fishing.

Oil Spills

The Buccaneer Field has a good record in terms of oil spills. From September 1973 through March 1978, a maximum of about six barrels are reported to have been spilled, and three of those barrels were from an unknown source.

SOURCE	DATE	AMOUNT (gal)	COMMENTS
Platform 296-B	9-28-73	21	0.5 barrels
Unknown	11-26-73	126	3.0 barrels
Platform 288-A	7-21-74	21	0.5 barrels
Platform 296-B	8-06-74	70	1.7 barrels, leak in line
Platform 288-A	9-30-75	10-15	0.4 barrels
Platform 288-A	11-08-75	2	0.04 barrels
Platform 288-A	2-10-78	2-3	0.05 barrels
Platform 288-A	3-27-78	(?)	Sheen

We have not observed any oil spills from BOF platforms. On one occasion we observed a very short-lived discharge of condensate out the Production Platform 288-A flare stack.

Ecosystem Synopsis

The initial conceptual model of the system was based upon a prior literature review (Gallaway *et al.* 1976). That information was supplemented by results from the first year's BOF study and other sources, with the conceptual model being revised accordingly. Because they represent documentation for a large part of the current conceptual model, results of the initial literature review describing production platform communities in the northern Gulf of Mexico are included in this report. Contributions used from other sources (including the BOF investigations) are incorporated in sections describing parameterization of the model.

The composition of any ecosystem includes decomposer, producer, and consumer categories, each of which is dependent on the other category for its existence. Decomposers (reducers), primarily bacteria, are particularly important in that they degrade organic compounds, releasing the contained inorganic nutrients to producers. They are also important in that they utilize and convert dissolved organic carbon to particulate organic carbon which becomes available as food source for protozoa, copepods, filter feeders, detritus feeders, and grazing animals in general (ZoBell 1954). Relative to these studies, reducers are particularly important in that many can degrade petroleum hydrocarbons. In an undated publication, circa 1974, the Gulf Universities Research Consortium (GURC), state that, in the Timbalier Lease Area offshore Louisiana, hydrocarbon degradation during 1972-1973 occurred at a rate at least equal to the rate of hydrocarbon production (or introdution) from all sources.

Producers in the Gulf of Mexico are phytoplankton, primarily diatoms and dinoflagellates. Additionally, filamentous green algae, red algae, and sessile diatoms colonize offshore structures. Primary production is a major source of particulate organic carbon for the Gulf system.

Consumers in the Gulf ecosystem are represented by zooplankton, macroinvertebrates (in- and epifaunal), fishes, sea turtles, and mammals. The more abundant groups of offshore zooplankton include copepods (usually dominant), larvaceans, ostracods, molluscs, and chaetognaths (Angelovic 1976). Zooplankton feed primarily upon phytoplankton and other particulate organic carbon.

In terms of macroinvertebrates, the Buccaneer Field is situated in a region of the Gulf of Mexico designated as the "shrimp ground community" by Hedgpeth (1954). By his definition this area extends from the foot of the sandy beach to the offshore 10-15 fathom contour line. Hedgpeth described the characteristic invertebrates as white shrimp, *Penaeus setiferus*; the epifaunal sea pansy, *Renilla mulleri*; and the gorgonian, *Leptogorgia setacea*. He noted that tube building worms (Onuphidae), crabs (*Hepatus, Calappa, Persephone)*, anemones, gastropods, hermit crabs and stomatopods were also common. Hann (1973) described the invertebrate fauna of this zone to be a part of the "inner shelf assemblage" (2-12 fathoms, sand or mud or mixed sand and mud bottoms, salinity = 36 ppt).

Farrell (undated) described benthic communities sampled during 1972-1973 in the vicinity of an offshore producing oil field in the Louisiana Gulf. Collections of benthos were made by van Veen grab and a small biological trawl. Common invertebrates collected 100 m from a platform (water depth = 63 ft) were *Oxyurostylis smithi*, *Monoculoides nyeri*, *Stenothoe minuta*, *Synchelidium* sp., and *Lembos* sp. while benthos dominants from a control area 2 mi away were *Oxyurostylis smithi*, *Snchelidium* sp., *Latreutes parvulus*, *Ampelisca vadorum*, and *Monoculoides nyeri*.

Studies on fouling organisms associated with offshore structures in Louisiana and Texas have been reported by Gunter and Geyer (1955) and George and Thomas (undated). These studies describe the zonation and composition of organisms growing on platform structures. The former study reported that barnacles, hydroids, horse oysters (*Ostrea equestris*) and bryozoans (*Acanthodesia* sp.) dominated the community on the lower 25 ft of Texas platforms. Gunter and Geyer also described colonization of steel pipe experimentally placed at different depths. On these substrates, *Balanus improvisus*, hydroids, *Corophium* and anemones dominated the composition of the fouling mat; additionally, *Crassostrea virginica*, *Thais*, and *Menippe* were found at upper levels while *Ostrea equestris*, *Arca* sp., *Crepidula*, serpulid worms, and corals were growing at lower levels.

George and Thomas described seasonal and vertical variations in the species composition and density of the fouling community. Numerous sessile and motile animals were found interspersed throughout algae mats near the surface. Among those organisms were hydroids, amphipods, xanthid crabs, pycnogonids, and barnacles. The barnacles *Balanus reticulatus* and *B. improvisus* were found in a 55-45% ratio. From 8 to 20 ft depths the algae-hydroid zone was replaced by anemones; barnacles become larger in size with *B. reticulatus* representing 70% of the barnacle population. Motile components included amphipods (*Corophium*, *Stenothoe*, *Caprella*), xanthid crabs, and blennies. Below 25 ft, down to 35-40 ft, hydroids dominated and barnacles became less dense. Below 40 ft hydroids completely dominated with only a few dead barnacles and some serpulid worm tubes present.

George and Thomas concluded that seasonal changes were marked by maximum densities of fouling organisms during summer with decreases in the fall. Changes in amphipod species composition, biomass, and density were noted. Algal biomass was lowest in winter and highest in summer.

George and Thomas compared fouling communities of the northwestern Gulf to similar communities in the northeastern Gulf as described by Pequegnat and Pequegnat (1968). They observed that sponges, corals, and tunicates dominated communities in the east while barnacles and hydroids were biomass dominants in the northwestern Gulf.

Hoese (1958) listed 424 species of fishes known to occur in the Gulf of Mexico along the Texas coast. Moore (1975) added 62 species to Hoese's checklist and none were "additions" related to changes in taxonomic status. Of interest, 29 of those species are typical members of coral reef fish faunas. Further, Moore noted that his additions did not include some tropical species recently collected or seen over the Flower Gardens and at offshore oil platforms in the northwestern Gulf of Mexico. In contrast to inshore environments, he observed that the reef fauna may be present year-round on offshore structures where environmental fluctuations are minimized and considerable invertebrate populations are present.

Kilma and Wickham (1971) and Wickham *et al.* (1973) documented the effectiveness of artificial structures and floating objects in attracting fishes. In the former investigations, the authors found that two general species groupings were associated with the artificial structures they employed: "baitfish" and "jacks." Baitfish consisted of round scad (*Decapterus punctatus*), Spanish sardine (*Sardinella anchovia*) and scaled sardine (*Harengula pensacolae*). The "jack" category included amberjack (*Seriola* sp.), rainbow runner (*Elagatis bipinnulatus*), and the blue runner (*Caranx chrysos*). Incidental species were always represented by few individuals; included were remora (Echeneidae), file fish (Balistidae) and others.

Large variations in daily numbers of fish were observed by Kilma and Wickham, but as many as 10,000 fish were estimated around the structure one day after it was positioned. Another significant finding was that the congregations of fishes were transient in nature with schools constantly moving into and away from structures.

Baitfish and jacks maintained different spatial relationships with the structures. Baitfish were normally in the upper half of the water column either around the structure or upcurrent from it. Jacks stayed either at the level of the structure or below it, seldom swimming above. Baitfish preferred mid-water structures and jacks preferred surface structures.

Feeding was observed among baitfish but never among jacks. Although large predators were infrequently observed, considerable evidence of their presence and feeding was noted in the form of both mutilated jacks and baitfish. The authors interpreted their data as evidence that the initial attraction of fishes to structures is probably the result of a visual stimulus provided by a structure in the optical void of the pelagic environment.

Wickham *et al.* (1973) observed that pelagic game fish are also attracted to artificial structures and the attraction seems to involve species-specific behavioral mechanisms. King mackerel (*Scomberomorus cavalla*) and little tuny (*Euthynnus alletteralis*) were seldom observed unless baitfish were present, but dolphin (*Corphaena hippurus*), cobia (*Rachycentron canadum*), and great barracuda (*Sphyraena barracuda*) were attracted to the structure *per se*. They presented evidence that baitfish are able to use artificial structures for predator avoidance. They believe that the competing visual stimuli of structures disrupts the predator's visual fix on the prey required for a successful attack.

Shinn (1974) and Sonnier *et al.* (1976) have described fish populations around oil platforms in the northwestern Gulf of Mexico, and Hastings *et al.* (1976) described fish populations around U.S. Navy research platforms in the northeastern Gulf. Shinn, in discussing the advantages of oil platforms as artificial reefs, described the distribution of the turbid, or nepheloid layer, that lies over much of the bottom of the northwestern Gulf. This bottom murky layer can be as much as 20-30 ft thick and reduces light penetration to the extent that algae cannot exist over much of the bottom. The GURC investigations showed that this layer is probably associated with Mississippi River discharge rather than commercial trawling or oil production activities.

Shinn also described the vertical zonation of fishes around the platforms. He listed spadefish (*Chaetodipterus faber*), barracuda, lookdown (*Selene vomer*) and sheepshead (*Archosargus probatocephalus*) to be characteristic of the upper water layers; red snapper (*Lutjanus campechanus*) and large groupers (*Epinephelus nigritus, Epinephelus itajara*) were described to be largely bottom fish but that they spent some of their time in the mid-water layers; and, restricted to the bottom were speckled trout (*Cynoscion nebulosus*), sand trout (*Cynoscion* sp.) and flounders (*Paralichthys* sp.).

Sonnier *et al.* (1976) working in the Gulf offshore Louisiana compared fish faunas of natural reefs to those around oil platforms. They found that natural reefs contained more species than oil platforms, although a number were common to both and 12 species were found only around platforms. In the more offshore areas (50-100 fathoms), a tropical fauna was characteristic of the reefs and, at inshore reefs and platforms, the tropical fauna was replaced by more temperate species such as sheepshead, lookdown (*Selene vomer*) and gray snapper (*Lutjanus synagris*). The most distinctive platform fishes were soapfish (*Rypticus maculatus*), warsaw, jewfish, and spadefish. Crested blenny (*Hypleurochilus geminatus*) and two filefishes (*Aluterus schoepfi* and *Monacanthus hispidus*) were among the 12 species observed only at platforms. Jacks, spadefish, and king mackerel were pelagic species common to both artificial and natural reefs. Sonnier *et al.* (1973) believe that representatives of the reef and the platform-associated communities may be year-round residents rather than seasonal migrants. They reported that Felder (1971) observed that benthic fishes closely associated with reefs fed on reef organisms, but that nektonic species did not.

Hastings *et al.* (1976) found that in the northeastern Gulf, platform pilings and cross-members with their encrusting organisms and associated motile fauna provided food and shelter for numerous fish species. Organisms that were observed grazing on the fouling community included spadefish, filefish, chubs, sparids, and some grunts. Surprisingly, they found spadefish normally associated with the bottom water layers. Most of the rig grazers were diurnal and became inactive at night.

Several diurnally schooling species were found to be abundant beneath the platforms during the day where they were afforded some protection from predation (Hastings *et al.* 1976). These fishes dispersed into surrounding open areas at night to feed. Examples showing this feeding behavior were clupeids, carangids, lutjanids, and grunts. Large numbers of piscivorous fish appeared attracted to the platform habitat to feed on the numerous smaller fishes associated with the structure. Many species migrated away from the platforms during the colder months and repopulation by these forms occurred during spring and summer.

Non-fish predators associated with the system include sea turtles and aquatic mammals. Four sea turtles have been recorded offshore the Texas coast: the Atlantic loggerhead (*Caretta caretta*), Atlantic green (*Chelonia mydas*), Atlantic Ridley (*Lepidochelys kempi*) and the Atlantic leatherback (*Dermochelys coriacea*) (Thomas 1974). Sixteen species of aquatic mammals have been recorded from the Texas coast. Only 2 species, the bottle-nosed dolphin (*Tursiops truncatus*) and the pilot whale (*Globicephala melaena*) are considered common in offshore waters (Davis 1974).

METHODS

The conceptualization of the system was determined to be best presented in the form of a compartmental model. In this format, all components of the system were assigned to a compartment, or box, with the interactions among compartments (mostly trophic) represented as arrows. In general, ecosystem models are developed using either energy or biomass units. We chose to use wet weight biomass (kg) as units because of the nature of the results of ongoing studies in the BOF and because changes in biomass can be particularly useful for evaluating environmental impacts. The specific form chosen for initial approximation of income and loss rate expressions was a set of linear, donor-controlled equations. We were cognizant of the problems associated with the use of these equations for systems modeling, but believed that the approach would enable us to adequately test whether or not production platform community dynamics could be explained in terms of resource limitations. The concept of resource limitation is acceptable for offshore production platform communities since primary production is dependent upon surface area, nutrients and light available, and other organisms could be attracted to the area in proportion to food available there.

The boundary of the system was established as a 45.5-m radius of influence emanating from the center of the production platform. This results in a bottom area of 6.57×10^3 m^2 and a water volume of 1.4×10^5 m^3. The surface area of the production platform was calculated to be 3.8×10^3 m^2.

Initially, we structured the model with 17 compartments (Gallaway *et al.* 1976). That model was reduced to 10 compartments (Fig. 3). Initial conditions of the state variables and transfer coefficients were based upon summer data. In general, the trophic requirements of each compartment were derived based upon assimilation efficiency (eff) and an appropriate turnover time:

$$\text{Requirements} = \text{Standing Stock} \times \text{Turnover} \times \frac{1}{\text{eff}}$$

In cases where there were no data describing preferences for one or more of an array of inputs or food sources, utilization was assumed to be on a proportionate basis among all possible sources. For example, if compartment X_i needed y kg based upon the above equation and X_i received inputs from X_j, X_k, and X_l, the transfer from X_j to X_i was estimated

$$T_{x_i x_j} = Y \frac{X_j}{X_j + X_k + X_l}$$

Transfers from X_k and X_l were calculated in the same fashion. Coefficients for the steady state model were then derived using these transfers such that the coefficient multiplied times the appropriate standing stock equated $T_{x_i x_j}$.

Some of the biotic donor compartments were not large enough to provide the amount of material needed based upon the above method. Under those circumstances, the transfer coefficients were adjusted such that the amount taken from the biotic compartments was reduced and the amount taken from the particulate organic carbon (POC) compartment was increased by the same amount in order to obtain mass balance. Thus, the model is essentially POC based. We believe that the assumption of a POC based system is reasonable in light of our observations made in the field. We further believe that this will prove to be one of the more significant findings of the BOF program. Inputs to POC from all compartments and ingestion of suspended particulates are considered priority data needs that are apparently being addressed in the third year of study (e.g., studies of suspended particulates initiated during the course of the past contract year and the emphasis on sedimentology for the present record year).

The model was parameterized as above for both steady state and seasonally varying conditions based upon a quarterly time step. Most of the data being collected in the BOF investigations are gathered on a quarterly basis. Once parameterized, the steady state model was tested for asymptotic stability and subjected to flow analysis to determine sensitivity.

The type of equilibrium stability reflected by a model is an important consideration in determining its validity or appropriateness for simulating ecosystem behavior. Padulo and Arbib (1974) define 3 types of equilibrium stability: unstable, weakly stable, and asymptotically stable. In the case of unstable equilibrium, any perturbation causes the system to move from equilibrium without return. Equilibrium of weakly stable systems will not change in response to a perturbation or displacement. Models with asymptotically stable equilibrium will return to equilibrium after perturbation once nominal inputs are resumed.

Linear systems will exhibit asymptotic stability if eigen values (λ) of the system are negative. In general, an n X n system has, at most, n eigen values. The proposed model is 10 X 10 and thus has 10 eigen values. The values were calculated

$$\det (\underset{\sim}{\lambda}\ I - A) = 0$$

where det = determinant of the matrix, $\underset{\sim}{\lambda}$ vector of eigen values, I = identity matrix, and A = flow coefficient matrix.

Flow analysis techniques followed Finn (1976) and were based upon the following parameters. Each compartment was analyzed for the amount (kg) of material flowing through during a 1-yr period (throughflow, T_k). The sum of all compartment throughflows were used to estimate total system throughflow (TST). The TST values were partitioned into a portion due to cycled throughflow (TST_c) and a portion due to straight throughflow (TST_s).

Average path length (APL) characteristics were also determined as part of the flow analysis following Finn (1976). APL is defined as the expected number of times an inflow or outflow passes through any component in the system. An equivalent definition is the average number of components an inflow (APLZ) passes through before leaving the system, or the average number of components an outflow (APLY) has passed through since entering the system.

Average path length (APL) was determined and is defined as the number of components of the system an average inflow or outflow can be expected to pass through. This value represents a weighted mean of APLZ or APLY. APL was partitioned into a portion due to cycled flow (PL_c) and a portion due to straight throughflow (PL_s). The variance of the APL of inflows was designated VZPL and for outflows, VYPL.

In the model, some compartments are important in that they transport materials from outside the system into the system. Each compartment was evaluated in terms of its importance in this respect by dividing the amount of material it transported into the system by the total amount of material coming into the system from the environment.

The cycling efficiency for each compartment was calculated as the ratio of cycled throughflow to total throughflow. The cycling index (CI) for the system was calculated as the ratio of cycled total system throughflow (TST_c) to total system throughflow (TST).

Using the above parameters, we were able to determine which pathways and compartments were most important in terms of system inputs, cycling and outputs as well as to compare our model to other system models. The results of the flow analysis outputs were used to predict where material from the platform should flow and the effects of reducing or increasing certain flows.

RESULTS AND DISCUSSION

The mathematical expression of the conceptual model with a summary description for each compartment is shown as Table 1. Descriptions of each compartment, or state variable, including initial conditions (summer) and associated coefficients are presented below and are followed by sections presenting results and interpretations of flow analysis and simulations.

Compartment X_1, Fouling Flora

Fotheringham (1977) found the fouling flora on BOF production platforms consisted of grean algae (Chlorophyceae, 8 species), red algae (Rhodophyceae, 7 species), and brown algae (Phaeophyceae, 1 species).

This producer biomass has not been measured. To obtain the initial standing stock value, we estimated that the flora comprised about 5.3% of the total fouling community biomass. Based upon the results obtained in Work Unit 2.3.8, a total of 1,147 kg of algae was assumed to have been attached to the production platform during the summer season.

The dynamics of the fouling flora compartment are described

$$\frac{dX_1}{dt} = G_{113} - (T_{51} + P_{101} + L_{141})X_1$$

where G_{113} = gross plant production, T_{51} = loss to grazers, P_{101} = loss to particulates, and L_{141} = environmental losses (respiration, maintenance, etc.). Values calculated for each transfer coefficient under steady state and time varying conditions are presented in Table 2. In the absence of appropriate data, we set P_{101} and L_{141} to 0 such that net production is growth minus grazing losses.

Compartment X_2, Fouling Fauna

This compartment contains a complex assemblage of organisms and may need to be separated into several compartments once more data become available. In terms of biomass, the compartment is dominated by habitat formers (barnacles, bivalve molluscs, etc.) which are covered by an interspersion of bryozoans, hydroids, and sponges, which form a covering mat. Blennies, xanthid crabs, and pistol shrimp are closely associated cryptic forms living in the recesses of the habitat formers, and the fouling mat is literally "alive" with polychaetes, nematodes, and amphipods.

The summer standing stock value for the faunal fouling community on the production platform (21,653 kg) was based upon biomass results obtained by representatives of Work Units 2.3.8 and 2.3.5. The turnover time for X_2 was estimated to be 1 yr and the assimilation efficiency was assumed to be 20% of ingestion. The dynamics of this compartment are represented in the model:

$$\frac{dX_2}{dt} = T_{24}X_4 + T_{210}X_{10} + G_{213} - (R_{32} + T_{52} + P_{102} + L_{142})\ X_2$$

where T_{24} = ingestion of holoplankton, T_{210} = ingestion of particulates, G_{213} = environmental gains (oxygen, dissolved organics, etc.), R_{32} = reproduction losses, T_{52} = losses to grazers, P_{102} = loss to particulates (fecal losses and die-off) and L_{142} = environmental losses (respiration, maintenance, etc.). Internal grazing is included as part of respiration.

The values calculated or assigned to the respective coefficients are presented in Table 2. Due to mass balance, most of the input to the fouling fauna comes from X_{10}, suspended particulates. This coefficient ranges from 602.2775 in winter and fall to 669.1917 in spring and summer.

Holoplankton (X_4) also provides seasonally varying inputs and the environmental gain term (G_{213}) was set to 0. This compartment increases in winter due, in our model, to decreased predation (T_{52}) by grazers or "fouling feeders" (X_5). Both the abundance and feeding rates of the grazers are believed to be lower in winter than during other seasons. The remaining loss terms were considered seasonally invariant ($R_{32} = 5.6343$, $P_{102} = 0.893132$, $L_{142} = 0.0130235$).

Compartment X_3, Meroplankton

The plankton data obtained at a BOF production platform by Fotheringham (1977) were used as a basis for describing meroplankton composition and abundance. This investigator made seasonal day and night collections at the surface using 0.5-m conical nets and a 1.0-l Kemmerer water sampler. We used the daytime density estimates and extrapolated the results to a depth of 21.2 m. The data were presented as numerical densities. The numerical densities were changed to biomass densities by estimating the volume of the average individual and converting volume to biomass. Using this method, the summer standing stock of meroplankton in the system was 9.28 kg. The meroplankton included 18 categories of larval stages including Cirripedia nauplii and cypris, Porifera larvae, polychaete larvae, brachyuran zoea and hydromedusae.

We assumed 9 generations of holoplankton per year characterized by a 20% assimilation efficiency. The dynamics of this compartment are represented in the model

$$\frac{dX_3}{dt} = R_{32}X_2 + R_{35}X_5 + R_{36}X_6 + R_{37}X_7 + R_{38}X_8 + R_{39}X_9 + T_{310}X_{10} + M_{312} + G_{313} - (T_{63} + T_{73} + P_{103} + M_{123} + L_{143})\ X_3$$

The coefficients designated by an R indicate gains resulting from reproduction by the designated compartments, T_{310} represents ingestion of particulates and the terms M_{312} and M_{123} represent drift into and out of the system, respectively. The term G_{313} represents environmental gains (oxygen, dissolved organics, etc.) and the corresponding environmental loss (respiration, maintenance, etc.) term is designated L_{143}. The predation coefficients T_{63} and T_{73} represent losses to plankton feeders and benthos, respectively. Values derived for each coefficient are shown in Table 2.

Inputs from eggs of fishes (R_{35}, R_{36}, R_{38}, R_{39}) were assumed to be 10% of each respective donor compartment, and fish fecundity during winter and fall was assumed to be half of the spring and summer rates. Contributions of eggs from the fouling fauna to meroplankton biomass (R_{32}) was assumed to be constant throughout the year, i.e., some species included in this compartment are spawning during each season. Contributions of meroplankton estimated to come from the benthos were derived from data provided by Harper (1977).

Compartment X_4, Holoplankton

An initial estimate of the standing stock biomass of holoplankton during the summer season, 59.3 kg, was also derived from Fotheringham's (1977) data as described above under Meroplankton. Holoplanktonic organisms included larvaceae, ostracods, calanoid copepods, hyperiid amphipods and chaetognaths. Phytoplankton are included in this compartment. Holoplankton were assumed to have 6 generations per year and an assimilation efficiency of 20%.

The dynamics of the holoplankton compartment are estimated

$$\frac{dX_4}{dt} = T_{410}X_{10} + M_{412} + G_{413} - (T_{24} + T_{64} + T_{74} + P_{104} + M_{124} + L_{144})X_4$$

where T_{410} = ingestion of particulates, M_{412} = drift of holoplankton into the system, G_{413} = environmental gains (oxygen, dissolved organics, gross primary production, etc.); T_{24}, T_{64}, and T_{74} represent predation losses to the fouling fauna, plankton feeders, and benthos, respectively; P_{104} - loss to particulates (fecal losses and death); M_{124} = drift out of the system and L_{414} = environmental losses. Current estimates of coefficient values are presented in Table 2. Winter and fall feeding by holoplankton was assumed to be 75% of the spring-summer value. Each of the drift terms was set to 0 as were the loss terms P_{104} and L_{144}. Losses to predators were considered to be greater in spring and summer than during fall and winter. The coefficients used result in a net increase of holoplankton during winter.

Compartment X_5, Grazers on Fouling Community

This compartment is dominated by the sheepshead during all seasons. During spring and summer, sheepshead are supplemented by triggerfish, butterfly fish, angelfish, and chubs. The initial estimate of the standing stock biomass of grazers (20,000 kg) was based upon time series photographic data collected at a BOF satellite jacket in summer 1976 by Russel E. Putt, Jr. as part of his M.S. research. Putt (MS in preparation) determined total fish density at this structure was 0.57 fish/m^3. Large predatory fishes were not well represented in his photographic sampling; nearly all the fish sampled fit our classification of either grazers (X_5) or plankton feeders (X_6).

Studies and observations of single species of grazers and plankton feeding fishes in the BOF indicate that density of these species is similar at different types of platforms (see Work Unit 2.3.8). We therefore believed that Putt's density estimates provided a reasonable data base from which to estimate standing stocks for Compartments X_5 (grazers) and X_6 (plankton feeders). We estimated the average fish in these compartments weighed about 0.5 kg, yielding a total system biomass of 39,900 kg. Grazers were considered only slightly more abundant than plankton feeders during summer and were assigned 20,000 of the total 39,900 kg. These fish were assumed to have a turnover time of 1 year and an assimilation efficiency of 20%.

The dynamics of the grazing component are modeled:

$$\frac{dX_5}{dt} = T_{51}X_1 + T_{52}X_2 + T_{510}X_{10} + M_{512} + G_{513} - (R_{35} + T_{85} + T_{95} + P_{105} + F_{115} + M_{125} + L_{145})X_5$$

where T_{51}, T_{52}, and T_{510} represent feeding on fouling flora, fouling fauna, and suspended particulates, respectively; M_{512} and M_{125} are migration in and out of the system; G_{513} and L_{145} are environmental gains and losses; and the remaining terms represent losses to reproduction (R_{35}), benthic feeders (T_{85}), large predators (T_{95}), and fecal material and mortality (P_{105}) and to sportsfishermen (F_{115}). The respective coefficient values are shown in Table 2.

Grazers are represented as donor controlled principally by X_1 and X_2. Feeding varies seasonally with fall-winter levels represented as being much lower than spring-summer levels (Table 2). Gains resulting from migration into the system are offset by losses to fishermen. Coefficients for migration out of the system and environmental gains and losses were set to 0.

Compartment X_6, Plankton Feeders

Plankton feeders were considered to include spadefish (by far the dominant) as well as species such as round scad and Spanish sardine. The standing stock biomass for this compartment, 19,900 kg, was estimated as described above under X_5. One turnover per year and an assimilation efficiency of 20% were assumed.

The inclusion of spadefish in this compartment as opposed to their inclusion in X_5 (grazers on X_2) may appear inappropriate. Undoubtedly, spadefish occasionally feed on organisms associated with the fouling community, but results of field investigations and observations indicate they predominately feed on suspended particulates and plankton. During summer 1977, stomach contents of spadefish were dominated by zooplankton and barnacle molts, the latter being very abundant in the water column. Results of food habit investigations of spadefish performed during winter and spring indicated that the principal food of spadefish during this period was the hydroid, *Tubularia crocea*. The water column was marked by high densities of this hydroid which was apparently undergoing a seasonal decline associated with warming water temperatures and was breaking loose from the platform substrate. Spadefish are seldom observed grazing on the fouling community. Based on these observations, we believed spadefish belonged in the plankton feeding compartment.

The dynamics of plankton feeders are modeled

$$\frac{dX_6}{dt} = T_{63}X_3 + T_{64}X_4 + T_{610}X_{10} + M_{612} + G_{613} -$$
$$(R_{35} + T_{86} + T_{96} + P_{106} + F_{116} + M_{126} + L_{146})X_6$$

Transfers representing feeding on meroplankton, holoplankton, and particulates are respectively represented as T_{63}, T_{64}, and T_{610}. Other gains are from migration (M_{612}) and the environment (G_{613}). Losses are to reproduction (R_{36}), benthic feeders (T_{86}), large predators (T_{96}), particulates (P_{106}), sportfishermen (F_{116}), migration (M_{126}), and the environment (L_{146}). The respective coefficient values are shown in Table 2.

Compartment X_4, holoplankton, did not contain enough material to provide its share of the income to plankton feeders (X_6) on a proportional basis. Based upon the above observations concerning plankton feeders, the additional amount needed was taken from the particulate compartment (X_{10}). Feeding on meroplankton (T_{63}) during winter was assumed to be 25% of the summer feeding rates allowing X_3 to increase in winter as seems to be indicated by Fotheringham's (1977) data. Feeding on holoplankton (X_4) and particulates (X_{10}) during winter was assumed to be 75% of summer levels. As was done for grazers, gains resulting from migration into the system are offset by losses to fishermen.

Compartment X_7, Benthos

Harper (1977) found that polychaetes and amphipods dominated the macrobenthos in the BOF and that meiobenthic populations in this area were dominated by nematodes, formanifera and harpacticoids. This investigator provided estimates of the numerical density of benthos around BOF production platforms, but biomass data were not taken. Data describing the biomass of benthos (Farrell undated) and polychaetes (Kritzler undated) around production platforms offshore Louisiana were taken during the GURC studies performed during the early 1970's. Using a combination of these data sources, we estimated the summer standing stock of benthos in the BOF system to be 297 kg wet weight. Benthos were assumed to have an assimilation efficiency of 20% and a turnover rate of 2 times per year.

The equation describing the benthos is as follows.

$$\frac{dX_7}{dt} = T_{73}X_3 + T_{74}X_4 + T_{710}X_{10} + G_{713} - (R_{37} + T_{87} + P_{107} + L_{147})X_7$$

Benthos are depicted as feeding on meroplankton, holoplankton and particulates with additional gains coming from the environment. Their losses are to reproduction, benthic feeders, particulates, and the environment. Coefficient values are shown in Table 2.

Benthic feeding during winter was assumed to be 75% of the summer rate. More than a proportionate share of the input to benthos was required from the particulate compartment in order to meet mass balance.

Compartment X_8, Benthic Feeders

This compartment contains a complex assemblage of bottom feeding fishes and invertebrates. Species important to man include penaeid shrimp, snappers, flounders, and catfish. Reef fishes in this category include cubbyu and slippery dick. The standing stock of benthic feeders was estimated from trawl catch data. Unfortunately, we were unable to use BOF trawl catch data because the collections were made on a time basis and the trawling time varied greatly among collections. Based upon extensive trawling experience in the Gulf of Mexico offshore Texas, Dr. M. Chittenden, Texas A&M University (personal communication), estimated biomass of benthic consumers was about 0.25 kg/m_2. We used this figure to estimate the 1688 kg standing stock biomass of benthic feeders. Benthic consumers were assumed to turn over once per year and have an assimilation efficiency of 20%.

The model equation for this compartment is

$$\frac{dX_8}{dt} = T_{85}X_5 + T_{86}X_6 + T_{87}X_7 + T_{810}X_{10} + M_{812} + G_{813} - (R_{38} + T_{98} + P_{108} + F_{118} + M_{128} + L_{148})X_8$$

Benthic feeders prey upon fouling feeders (X_5), plankton feeders (X_6), benthos (X_7), and ingest particulate material (X_{10}). Additional gains come from migration (M_{812}) and the environment (G_{813}). Losses occur to reproduction (R_{38}), large predators (T_{98}), particulates (P_{108}), fishing (F_{118}), migration (M_{128}), and the environment (L_{148}). Coefficient values are presented in Table 2. Winter uptake rates were assumed to be 75% summer uptakes.

Compartment X_9, Large Predators

This compartment includes bluefish, sharks of various kinds, barracuda, mackerels (particularly king mackerel), cobia (locally known as ling), little tunny, and large jacks (carangids). Large schools of sizable bluefish, a species listed by Fotheringham (1977) as transient in the BOF, were noted around production platforms during all seasons of 1977 and 1978. Schools of blue runner were similarly abundant. A few hammerhead sharks were nearly always observed making a circuit around the production-quarters platform complex during spring and summer. Barracuda were common and cobia were infrequently observed. Each of these species is more or less solitary and a favorite target of sport fishermen and divers. Schools of mackerel and other scombrids were occasionally noted in close proximity to the production platform during warm seasons. Of the predators, bluefish was the only species observed actively feeding around the structures, particularly at night.

The standing stock of large predators was estimated based upon diver observation and hook-and-line collections. Based upon our catches we estimated that the average bluefish weighed about 1500 g. The divers estimated as many as 3000 bluefish were typically associated with a production platform during summer for a total of 4500 kg. The resident hammerhead was estimated to weigh about 40 kg. Other predators were assumed to represent about 522 kg such that the total standing stock was estimated to be 5062 kg. Turnover time was assumed to be 1 yr and assimilation efficiency was set at 20%.

The dynamics of the large predator compartment are modeled

$$\frac{dX_9}{dt} = T_{95}X_5 + T_{96}X_6 + T_{98}X_8 + M_{912} + G_{913} - (R_{39} + P_{109} + F_{119} + M_{129} + L_{149})X_9$$

Large predators are depicted as feeding on fouling feeders (X_5), plankton feeders (X_6), and benthic feeders (X_7), i.e., they primarily utilize other fish as food. Additional gains result from migration (M_{912}) and the environment (G_{913}). Losses are depicted as being to reproduction (R_{39}), particulates (P_{109}), fishing (F_{119}), migration (M_{129}), and the environment (L_{149}). Respective coefficient values are shown in Table 2. As the majority of the large predators, bluefish and blue runner, appeared abundant during all seasons, feeding rates were not varied by season.

Compartment X_{10}, Particulates or POC

As indicated by the model equation

$$\frac{dX_{10}}{dt} = P_{101}X_1 + P_{102}X_2 + P_{103}X_3 + P_{104}X_4 + P_{105}X_5 + P_{106}X_6 + P_{107}X_7 + P_{108}X_8 + P_{109}X_9 + M_{1012} + (H_{1011} + H_{1015}) - (T_{210} + T_{310} + T_{410} + T_{510} + T_{610} + T_{710} + T_{910} + M_{1210})X_{10}$$

all compartments contribute to X_{10} plus there is particulate drift into the system. Contributions can also come from the platforms (e.g. food scraps and particulates in produced water discharges). Compartments ingesting particulates include fouling fauna (X_2), mero- and holoplankton (X_3, X_4), fouling feeders (X_5), plankton feeders (X_6), benthos (X_7), and benthic feeders (X_8). Particulates also drift out of the system

(M_{1210}). The transfers (P_{10i}'s) were considered time invariant assuming that metabolic activity was a major contributor in warm seasons whereas death and increased turbulence causing a lot of material to break loose from the platform added large amounts of particulates to the system during cold seasons. This compartment was considered to increase in winter. Particulate uptake during winter was lower than during summer and the input was held constant. Values that were used to represent the respective coefficients are shown in Table 2.

Stability Analysis

As indicated by the negative eigen values for each compartment (Table 3), the steady state version of the BOF model exhibits asymptotic stability. This characteristic infers that, following a system perturbation producing a deviation from normal behavior, the nominal state will eventually be restored if original inputs are resumed. This is a characteristic of the model; the ecosystem may react differently. A large perturbation could cause a structural change in the ecosystem such that it would not return to the equilibrium point ("structural instability," Patten 1978).

Flow Analysis

The flow analysis (Finn 1976) used for the BOF steady state model is an application of economic input-output analysis to ecological systems models in an effort to define the structure of these systems. This method of analysis determines (1) a measure of the total system output partitioned into portions due to cycled flow and straight throughflow, (2) how much flow is necessary to produce a given outflow, and (3) the compartmental throughflows and outflows caused by each inflow. Determination of the average path lengths of inflows and outflows are provided to show the average number of compartments through which a flow passes. The importance of cycling in the system is provided by a cycling index which allows a comparison of the modeled system to other systems models.

Cycling as used herein does not imply that energy is being degraded more than once, but rather that energy can be "used" without being degraded. For example, energy associated with structural or storage elements (e.g. cellulose, proteins, fats) of one compartment can be catabolized or used as a structural element by the subsequent compartment to which it is transferred. In our system, the same compartment may take up energy that it earlier discarded in the form of cells or mucous. Additionally, assimilation efficiency is considerably less than 100% such that there is an amount of egested material that is digestible. Cycling as defined does not violate thermodynamic principles.

As parameterized, the total system throughflow, or output, is 576,485 kg/yr of which 483,109 kg/yr represents cycled throughflow and straight throughflow accounts for the remaining 93,376 kg/yr. Compartments exceeding 100,000 kg/yr throughflow (Table 4) are fouling fauna (X_2, 107,403 kg/yr), plankton feeders (X_6, 100,099 kg/yr) and particulates (X_{10}, 206,776 kg/yr). Collectively, the planktonic, benthic, and floral components of the system (X_1, X_3, X_4, X_7, X_8) account for less than 12% of the total throughflow. Grazers on the fouling community (X_5) and large predators (X_9) account for in excess of 88,000 and 50,000 kg/yr throughflow, respectively (Table 4).

Inflow and outflow path length vectors of the BOF model compartments are shown in Table 5. The variance associated with the average inflow was 691.8 and, for the average outflow, 689.3. In the BOF model, the average inflow or outflow passes through 26.735 compartments with 4.330 of that average due to straight throughflow and 22.405 due to cycling.

Based upon importance values, the BOF model is particularly sensitive to changes in inflows associated with compartments X_9, large predators, and X_8, benthic feeders (Table 6). As currently modeled, this importance is primarily due to migration into the system. The same flows are shown as important in terms of outflows as these compartments have been assigned a high utilization rate by man (e.g. immigration was set equal to harvest).

The ratio of cycled total system throughflow to total system throughflow provides an index which indicates how many times further than the straight throughflow path length an average system inflow will travel because of cycling. The cycling efficiencies for each compartment are shown in Table 7; the cycling index, CI, for the BOF steady state model is 0.8380. As the CI is not sensitive to the number of compartments in a model, any two systems can be compared using this index as long as major cycling paths are treated similarly.

Flow analysis measures for several carbon models including the BOF model are shown in Table 8 (after Finn 1977). The BOF model is most similar to the fourteen-compartment salt marsh model. The Buccaneer model has a high cycling index (0.84) and a long average path length (26.7). This is unusual for marine models and could be an artifact of the modeling process since it was assumed that immigration of plankton equalled emigration. Thus, no figures for plankton migration were included. If inflow and outflow of plankton were included, the model's cycling index and path length would decrease.

Input flow analysis was performed for each compartment having an importance value as described above greater than 0, and for the particulate compartment which was assumed to be the base of the platform community. Results of that analysis are described by Figures 4-9. In these figures and similar ones shown describing results of outflow analysis, it is important to remember that the numbers on the arrows and boxes respectively represent flows and throughflows and, in the latter case, not standing stocks. Additionally, some of the flows were combined to simplify the figures. The purpose of the diagrams is to show, on a relative basis, which flows and compartments are most important given a specific unit of input. Of the inflow analysis diagrams, Fig. 9 is of particular interest as it represents where material introduced from the platform is predicted to flow. Based upon the model, particulates from the production platform should increase the throughflow in compartments X_2, fouling fauna; X_5, grazers on fouling fauna; X_6, plankton feeders; and X_{10}, particulates. If hydrocarbons are assimilated, barnacles, sheepshead, spadefish, and particulate material taken from the vicinity of the platform should exhibit higher hydrocarbon levels than those from control areas such as the satellite jackets.

Output flow analysis is diagrammed in Figs. 10-15. These figures represent inflows, throughflows, and intercompartmental flows necessary to produce a unit of outflow from the designated compartment. The notations are the same as for the inflow analysis. Of these, Fig. 15 is of interest as it represents a unit outflow from X_9, large predators. The flows depicted in the figure are those necessary for 1 kg of large predator fish yield.

Simulations

Simulations and sensitivity analysis were run using a FORTRAN computer program which is presented and documented in Appendix III. This program allows for simulation of both steady state and seasonal varying dynamics of the model. Steady state dynamics are not presented graphically since the annual standing stocks do not change from year to year and thus yield straight, horizontal lines for each compartment. As indicated by its negative eigen values, the current steady state version of the model exhibits asymptotic stability. Although the model was defined as stable, it is extremely sensitive to small changes in any of the flows.

With the exception of compartment X_1, fouling flora, the seasonal varying dynamics of system components were not well described using a linear, donor-controlled model format. As currently parameterized, the simulation for X_1, fouling flora, shows biomass peaks occurring in fall with the lowest levels occurring during spring and summer (Fig. 16). Actual locations of biomass peaks and amplitude of seasonal fluctuations of fouling flora have not been verified by field data but seem consistent with qualitative observations.

Simulations of the other compartments (X_2-X_{10}) using the seasonally varying coefficients (Table 2) resulted in explosively unstable dynamics. The amplitude of fluctuation in standing stocks was ever increasing and typically very high after only a few time steps. This characteristic led rapidly to negative values for standing stocks. We postulated this feature of the model to indicate that we had not allocated sufficient extra-system inputs and outputs, i.e., we had erroneously forced most of the trophic dynamics to occur within the confines of our system boundaries. To test this hypothesis, we isolated compartment X_2, fouling fauna. This state variable was selected because it was one for which we had reasonably good seasonal field data. We speculated that grazers on this community were probably obtaining a large amount of their food requirements from sources outside the system during most, or all, seasons, particularly spring and summer. This speculation was based upon observation of feeding forays out of the system by sheepshead to harvest floating rafts of sargassum. Further, we relaxed our conditions of donor dependency relative to the output from X_2 of unassimilated foods to particulates. Using this approach, losses to particulates were considered to be a constant percentage of the amount of materials consumed by the compartment as opposed to being a function of the size of the compartment. The simulations using this approach resulted in realistic, as well as stable, seasonal dynamics (Fig. 17).

The simulation predicts biomass peaks of fouling fauna during winter-spring. Both the magnitude and timing of the predicted peaks are consistent with quantitative field observations. Each of the submodels should be adjusted in a similar fashion upon the acquisition of adequate data. The steady state version of the model should also be revised to incorporate these changes.

The results of the above exercise provided us sufficient cause to believe the linear donor control model format was an invalid approach for modeling a production platform system. We recognize that the existing model could be tuned such that stable seasonal dynamics could be produced. However, we believe that this would be a futile effort because the concept of donor control is not a valid one for the Buccaneer System. Tuning would not provide any additional understanding of the system.

CONCLUSIONS

Attempts to model a BOF production platform community have led to the conclusion that the system is particulate-based and characterized by both a high cycling efficiency and exchange of materials with the surrounding environment. In these respects, the model of the system more closely resembles an estuarine ecosystem than an open marine system.

Contaminants introduced from the platform are predicted by the model to increase the throughflow in the fouling fauna, grazer, plankton feeder and particulate compartments. Thus, if hydrocarbons are assimulated, levels in barnacles, sheepshead and spadefish from the production platform should be higher than levels in the same organisms living at the satellite jackets. Suspended particulates and surficial sediments at the production platforms should also exhibit higher hydrocarbon (or other indicator contaminant) levels than control areas.

Linear donor-controlled equations provide a sensitive, but stable, solution for the steady state version of the current model. However, as currently formulated, these do not adequately describe expected patterns of seasonal dynamics. The seasonal dynamics can probably best be described in future versions of the model by a relaxation of donor dependencies and adoption of more mechanistic approaches. The system as modeled provides insights which should allow for development of mechanistic formulations controlled by external driving variables and provides project management with a framework within which to direct future research toward achieving this goal.

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APPENDIX I

TABLES

Table 1. Mathematical representation of the BOF conceptual model (a) with a summary description of each compartment.

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a. Formulas

$$\frac{dX_1}{dt} = G_{113} - (T_{51} + P_{101} + L_{141})X_1$$

$$\frac{dX_2}{dt} = T_{24}X_4 + T_{210}X_{10} + G_{213} - (R_{32} + T_{52} + P_{102} + L_{142})X_2$$

$$\frac{dX_3}{dt} = R_{32}X_2 + R_{35}X_5 + R_{36}X_6 + R_{37}X_7 + R_{38}X_8 + R_{39}X_9 + T_{310}X_{10} + M_{312}$$
$$+ G_{313} - (T_{63} + T_{73} + P_{103} + M_{123} + L_{143})X_3$$

$$\frac{dX_4}{dt} = T_{410}X_{10} + M_{412} + G_{413} - (T_{24} + T_{64} + T_{74} + P_{104} + M_{124} + L_{144})X_4$$

$$\frac{dX_5}{dt} = T_{51}X_1 + T_{52}X_2 + T_{510}X_{10} + M_{512} + G_{513} - (R_{35} + T_{85} + T_{95} + P_{105}$$
$$+ F_{115} + M_{125} + L_{145})X_5$$

$$\frac{dX_6}{dt} = T_{63}X_3 + T_{64}X_4 + T_{610}X_{10} + M_{612} + G_{613} - (R_{36} + T_{86}\ T_{96} + P_{106}$$
$$+ F_{116} + M_{126} + L_{146})X_6$$

$$\frac{dX_7}{dt} = T_{73}X_3 + T_{74}X_4 + T_{710}X_{10} + G_{713} - (R_{37} + T_{87} + P_{107} + L_{147})X_7$$

$$\frac{dX_8}{dt} = T_{85}X_5 + T_{86}X_6 + T_{87}X_7 + T_{810}X_{10} + M_{812} + G_{813} - (R_{38} + T_{98} + P_{108}$$
$$+ F_{118} + M_{128} + L_{148})X_8$$

$$\frac{dX_9}{dt} = T_{95}X_5 + T_{96}X_6 + T_{98}X_8 + M_{912} + G_{913} - (R_{39} + P_{109} + F_{119} + M_{129}$$
$$+ L_{149})X_9$$

Table 1. (cont'd)

$$\frac{dX_{10}}{dt} = P_{101}X_1 + P_{102}X_2 + P_{103}X_3 + P_{104}X_4 + P_{105}X_5 + P_{106}X_6 + P_{107}X_7$$

$$+ P_{108}X_8 + P_{109}X_9 + M_{1012} + (H_{1011} + H_{1015}) - (T_{210} + T_{310}$$

$$+ T_{410} + T_{510}) + T_{610} + T_{710} + T_{810} + M_{1210})X_{10}$$

b. Summary of Compartments

Compartment Code	Description	Initial Biomass (kg) (Summer)	Turnover Rate	Assimilation Coefficient
X_1	Fouling flora, attached plants including macroalgae	1,147	-	-
X_2	Fouling fauna, attached animals including those dependent upon the attached ones for habitat.	21,653	1/yr	0.20
X_3	Meroplankton, planktonic larvae produced by animals spending part of their life as non-plankton	9.28	9/yr	0.20
X_4	Holoplankton, includes both phyto- and zooplankton	59.3	6/yr	0.20
X_5	Grazers; animals browsing on compartments X_1 and X_2	20,000	1/yr	0.20
X_6	Plankton Feeders: Fish depending on plankton and other particulates for food.	19,900	1/yr	0.20
X_7	The infaunal benthos.	297	2/yr	0.20
X_8	Organisms feeding on the infauna; the benthic epifauna.	1,688	1/yr	0.20
X_9	Large predators; bluefish, sharks, barracuda etc.	5,062	1/yr	0.20
X_{10}	Particulate organic carbon	168	-	-

Table 2. Transfer coefficient values for the BOF production platform community model. See Table 1 for complete equations.

Coefficient	Steady State	Season Winter	Spring	Summer	Fall
G_{113}	313	228	342	454	228
T_{51}	0.272886	0.23390	0.311869	0.311869	0.23390
P_{101}	0	0	0	0	0
L_{141}	0	0	0	0	0
T_{24}	10.1180	8.61106	11.62494	11.62494	8.61106
T_{210}	635.7321	602.2725	669.1917	669.1917	602.2725
G_{213}	0	0	0	0	0
R_{32}	0.0056343	0.0056343	0.0056343	0.0056343	0.0056343
T_{52}	4.0484	1.61936	6.47744	6.47744	1.61936
P_{102}	0.893132	0.893132	0.893132	0.893132	0.893132
L_{142}	0.0130235	0.0130235	0.0130235	0.0130235	0.0130235
R_{32}	0.0056343	0.0056343	0.0056343	0.0056343	0.0056343
R_{35}	0.0989	0.06593	0.131867	0.131867	0.06593
R_{36}	0.095126	0.0634173	0.126835	0.126835	0.0634173
R_{37}	0.0075	0.005	0.01	0.01	0.005
R_{38}	0.102489	0.06833	0.13665	0.13665	0.06833
R_{39}	0.09858	0.06572	0.13144	0.13144	0.06572
T_{310}	2.482	2.12743	2.8366	2.8366	2.12743
M_{312}	0	0	0	0	0
G_{313}	0	0	0	0	0
T_{63}	420.474	168.1896	672.7584	672.7584	168.1896
T_{73}	32.3276	30.626	34.029	34.029	30.626
P_{103}	95.0431	95.0431	95.0431	95.0431	95.0431
M_{123}	0	0	0	0	0
L_{143}	0.0242439	0.0242439	0.0242439	0.0242439	0.0242439
T_{410}	10.5892	9.0765	12.1019	12.1019	9.0765
M_{412}	0	0	0	0	0
G_{413}	0.012028	0.012028	0.012028	0.012028	0.012028
T_{24}	10.1180	8.61106	11.62494	11.62494	8.61106
T_{64}	10.0	8.57143	11.4286	11.4286	8.57143
T_{74}	9.88196	9.3619	10.402	10.402	9.3619
P_{104}	0	0	0	0	0
M_{124}	0	0	0	0	0
L_{144}	0	0	0	0	0

Table 2. cont'd

		Season			
Coefficient	Steady State	Winter	Spring	Summer	Fall
T_{51}	0.272886	0.23390	0.311869	0.311869	0.23390
T_{52}	4.0484	1.61936	6.47744	6.47744	1.61936
T_{510}	4.43452	3.801	5.06802	5.06802	3.801
M_{512}	149.995	149.995	149.995	149.995	149.995
G_{513}	0	0	0	0	0
R_{35}	0.0989	0.06593	0.131867	0.131867	0.06593
T_{85}	0.20995	0.17996	0.23994	0.23994	0.17996
T_{95}	1.0586	1.0586	1.0586	1.0586	1.0586
P_{105}	3.06845	3.06845	3.06845	3.06845	3.06845
F_{115}	0.0075	0.0075	0.0075	0.0075	0.0075
M_{125}	0	0	0	0	0
L_{145}	0	0	0	0	0
T_{63}	420.474	168.1896	672.7584	672.7584	168.1896
T_{64}	10.0	8.57143	11.4286	11.4286	8.57143
T_{610}	565.5	484.714	646.286	646.286	484.714
M_{612}	599.9104	599.9104	599.9104	599.9104	599.9104
G_{613}	0	0	0	0	0
R_{36}	0.095126	0.0634173	0.126835	0.126835	0.0634173
T_{86}	0.20995	0.17996	0.23994	0.23994	0.17996
T_{96}	0.60859	0.60859	0.60859	0.60859	0.60859
P_{106}	4.08628	4.08628	4.08628	4.08628	4.08628
F_{116}	0.03015	0.03015	0.03015	0.03015	0.03015
M_{126}	0	0	0	0	0
L_{146}	0	0	0	0	0
T_{73}	32.3276	30.626	34.029	34.029	30.626
T_{74}	9.88196	9.3619	10.402	10.402	9.3619
T_{710}	12.00595	11.374	12.6378	12.6378	11.374
G_{713}	0.2276	0.2276	0.2276	0.2276	0.2276
R_{37}	0.0075	0.005	0.01	0.01	0.005
T_{87}	0.2088	0.17897	0.23863	0.23863	0.17897
P_{107}	9.4545	9.4545	9.4545	9.4545	9.4545
L_{147}	0.104377	0.104377	0.104377	0.104377	0.104377
T_{85}	0.20995	0.17996	0.23994	0.23994	0.17996
T_{86}	0.20995	0.17996	0.23994	0.23994	0.17996
T_{87}	0.2088	0.17897	0.23863	0.23863	0.17897
T_{810}	0.065476	0.056122	0.0748297	0.0748297	0.056122
M_{812}	4,500	4,500	4,500	4,500	4,500
G_{813}	0.130064	0.130064	0.130064	0.130064	0.130064
R_{38}	0.102489	0.06833	0.13665	0.13665	0.06833
T_{98}	0.6084	0.6084	0.6084	0.6084	0.6084
P_{108}	4.295	4.295	4.295	4.295	4.295

Table 2. cont'd

Coefficient	Steady State	Season			
		Winter	Spring	Summer	Fall
F_{118}	2.666	2.666	2.666	2.666	2.666
M_{128}	0	0	0	0	0
L_{148}	0	0	0	0	0
T_{95}	1.0586	1.0586	1.0586	1.0586	1.0586
T_{96}	0.60859	0.60859	0.60859	0.60859	0.60859
T_{98}	0.6084	0.6084	0.6084	0.6084	0.6084
M_{912}	16,000	16,000	16,000	16,000	16,000
G_{913}	0.1838	0.1838	0.1838	0.1838	0.1838
R_{39}	0.09858	0.06572	0.13144	0.13144	0.06572
P_{109}	6.6794	6.6794	6.6794	6.6794	6.6794
F_{119}	3.1608	3.1608	3.1608	3.1608	3.1608
M_{129}	0	0	0	0	0
L_{149}	0	0	0	0	0
P_{101}	0	0	0	0	0
P_{102}	0.893132	0.893132	0.893132	0.893132	0.893132
P_{103}	95.0431	95.0431	95.0431	95.0431	95.0431
P_{104}	0	0	0	0	0
P_{105}	3.06845	3.06845	3.06845	3.06845	3.06845
P_{106}	4.08628	4.08628	4.08628	4.08628	4.08628
P_{107}	9.4545	9.4545	9.4545	9.4545	9.4545
P_{108}	4.295	4.295	4.295	4.295	4.295
P_{109}	6.6794	6.6794	6.6794	6.6794	6.6794
M_{1012}	2.89154	2.89154	2.89154	2.89154	2.89154
H_{1011}	0	0	0	0	0
H_{1015}	0	0	0	0	0
T_{210}	635.7321	602.2725	669.1917	669.1917	602.2725
T_{310}	2.482	2.12743	2.8366	2.8366	2.12743
T_{410}	10.5892	9.0765	12.1019	12.1019	9.0765
T_{510}	4.43452	3.801	5.06802	5.06802	3.801
T_{610}	565.5	484.714	646.286	646.286	484.714
T_{710}	12.00595	11.374	12.6378	12.6378	11.374
T_{810}	0.065476	0.056122	0.0748297	0.0748297	0.056122
M_{1210}	0	0	0	0	0

Table 3. Eigen values for the Buccaneer Oil Field model (annual, steady state).

-0.22950
-0.27289
-5.06761
-6.96248
-7.51644
-9.59865
-9.86409
-30.05083
-547.60367
-1233.57958

Table 4. Throughflow vector for Buccaneer Model. Throughflow is the amount of flow that passes through a compartment during a time interval. Units are in kg wet weight per year.

Compartment		Throughflow
Fouling Flora	(X_1)	313
Fouling Fauna	(X_2)	107,403
Meroplankton	(X_3)	5,084
Holoplankton	(X_4)	1,779
Grazers	(X_5)	88,868
Plankton Feeders	(X_6)	100,099
Benthos	(X_7)	2,903
Benthic Feeders	(X_8)	12,950
Large Predators	(X_9)	50,310
POC	(X_{10})	206,776

Table 5. Inflow (APLZ) and outflow (APLY) path length vectors. Path length is the expected number of times an inflow or outflow passes through any compartment.

Compartment		APLZ	APLY
Fouling Flora	(X_1)	36.356	1.000
Fouling Fauna	(X_2)	36.678	37.169
Meroplankton	(X_3)	37.823	36.873
Holoplankton	(X_4)	38.059	37.164
Grazers	(X_5)	35.356	37.971
Plankton Feeders	(X_6)	36.551	36.981
Benthos	(X_7)	37.963	37.439
Benthic Feeders	(X_8)	24.694	25.453
Large Predators	(X_9)	26.672	26.401
POC	(X_{10})	37.641	36.164

Table 6. Importance values in percent total extra-system throughflow for the Buccaneer model. Importance values are the percent contribution an extra-system inflow or outflow makes to total extra-system flow.

Compartment		Inflow	Outflow
Fouling Flora	(X_1)	1.974	0.0
Fouling Fauna	(X_2)	0.0	1.818
Grazers	(X_5)	0.919	0.989
Plankton Feeders	(X_6)	3.804	3.849
Benthos	(X_7)	0.0	0.201
Benthic Feeders	(X_8)	19.276	19.276
Large Predators	(X_9)	74.026	73.275

Table 7. Cycling efficiencies for the Buccaneer Model. Cycling efficiency for a compartment is the ratio of cycled throughflow to total throughflow.

Compartment		Cycling Efficiency
Fouling Flora	(X_1)	0.0
Fouling Fauna	(X_2)	0.8703
Meroplankton	(X_3)	0.2476
Holoplankton	(X_4)	0.1027
Grazers	(X_5)	0.8445
Plankton Feeders	(X_6)	0.8641
Benthos	(X_7)	0.1616
Benthic Feeders	(X_8)	0.2637
Large Predators	(X_9)	0.6101
POC	(X_{10})	0.9289

Table 8. Flow analysis measures for carbon models (after Finn 1977). Flow measures include total inflow (Σz), total outflow (Σy), total system throughflow (TST), average path length (APL), straight throughflow pathlength ($\overline{PL_s}$), variance of inflow path length (VZPL), variance of outflow pathlength (VYPL), total system cycled throughflow (TST_c), and cycling index (CI).

Model	$\Sigma z = \Sigma y$	TST	$\overline{PL}$	$\overline{PL}_s$	VZPL	VYPL	TST_c	CI
Marine Coprophagy $g\ C\ m^{-2} y^{-1}$	379.6	549.3	1.45	1.27	0.550	.480	65.9	0.12
Salt Marsh Model 14 Comp. $g\ C\ m^{-2} y^{-1}$	1005.7	35011.2	34.8	7.84	1003.6	338.9	27127.6	.775
Salt Marsh Model 13 Comp. $g\ C\ m^{-2} y^{-1}$	9531.5	25479.7	2.67	2.55	3.57	.401	1150.8	.045
Ross Sea $mt.\ C\ y^{-1}$	32.7×10^6	88.9×10^6	2.20	2.04	0.434	.579	6.57×10^6	.074
Buccaneer g wet wt yr^{-1}	21.5×10^3	57.6×10^4	26.7	4.3	691.8	689.3	483.1×10^3	.838

APPENDIX II

FIGURES

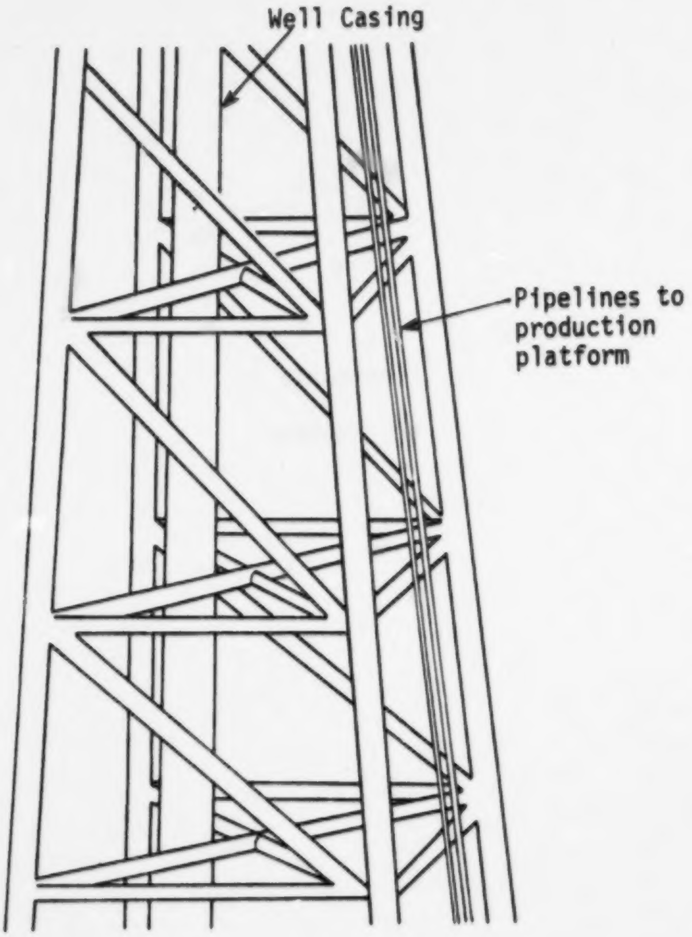

Well Casing
Pipelines to production platform

Fig. 1. Subsurface structure of a BOF satellite well jacket. A total of 548 m^2 hard-substrate habitat is provided by a satellite platform.

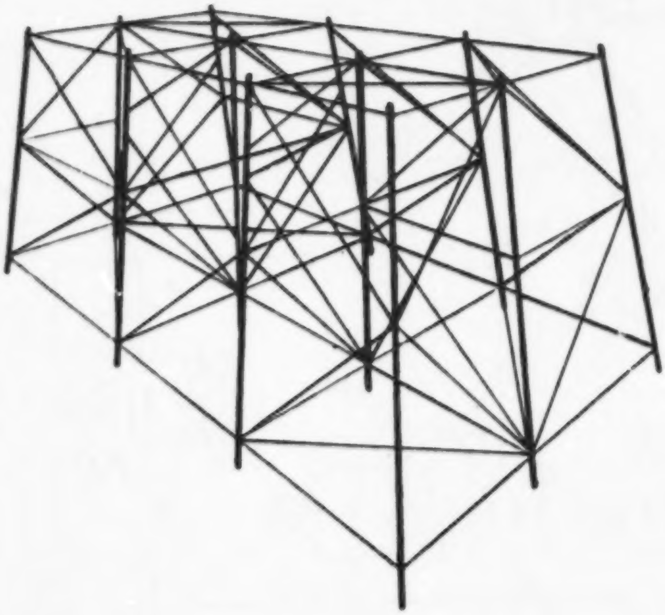
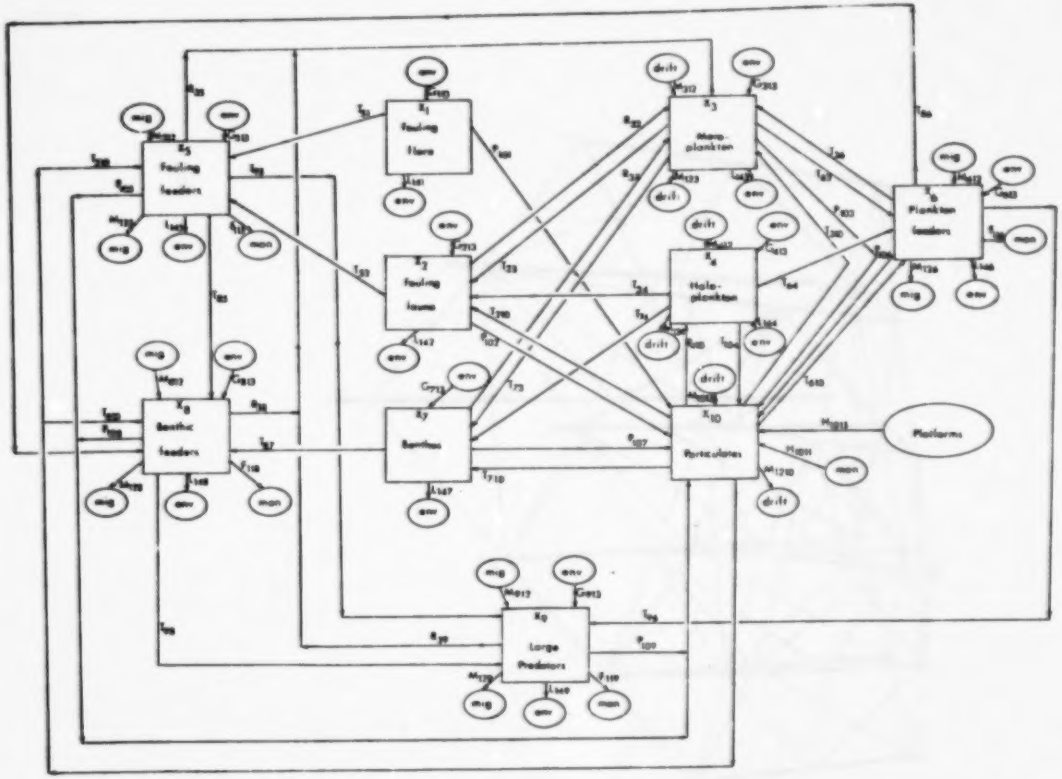
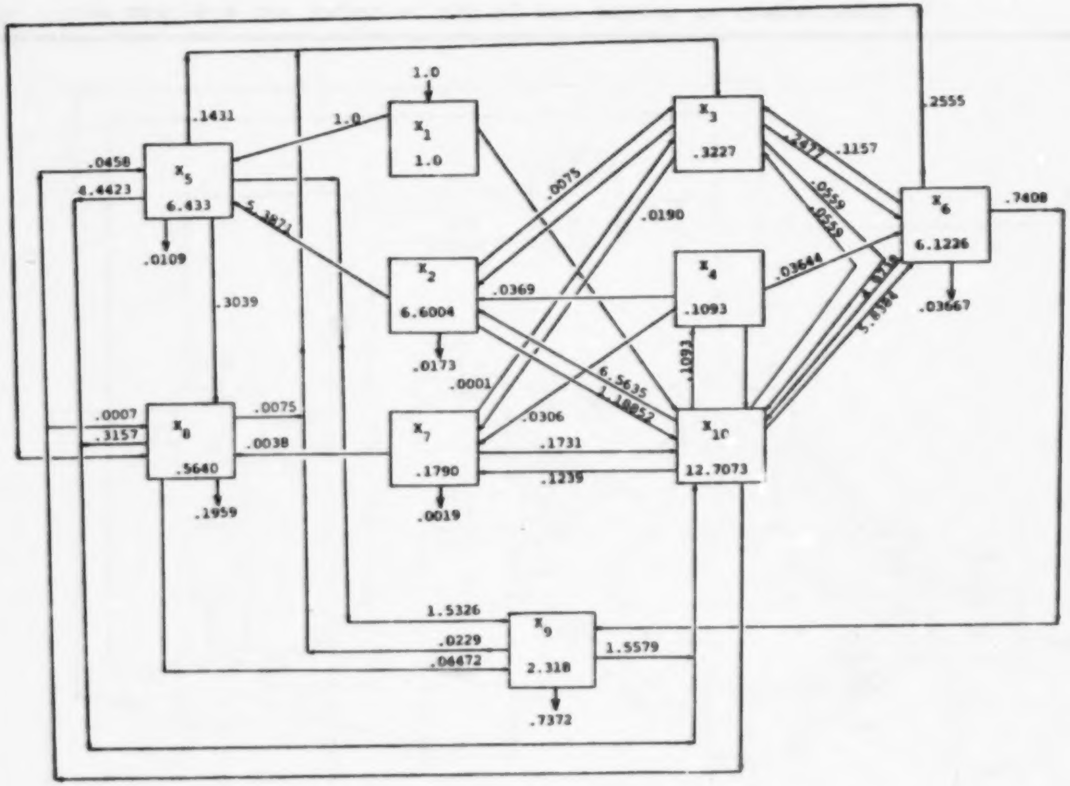


Fig. 2. Subsurface structure of a production platform in the BOF. Well casings and pipelines not shown. A total 3800 m^2 hard-substrate habitat is provided by this type of structure.



x_5 Fouling feeders
x_1 Fouling flora
x_3 Mero-plankton
x_6 Plankton feeders
x_2 Fouling fauna
x_4 Holo-plankton
x_8 Benthic feeders
x_7 Benthos
x_{10} Particulates
Platforms
x_9 Large Predators
mig
env
man
drift

Fig. 3. Conceptual compartment model for the Buccaneer Oil Field ecosystem. Drift refers to passive drift in or out of the system, mig refers to active migration in or out of the system, and env refers to environmental gains or losses.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1.0
x_5
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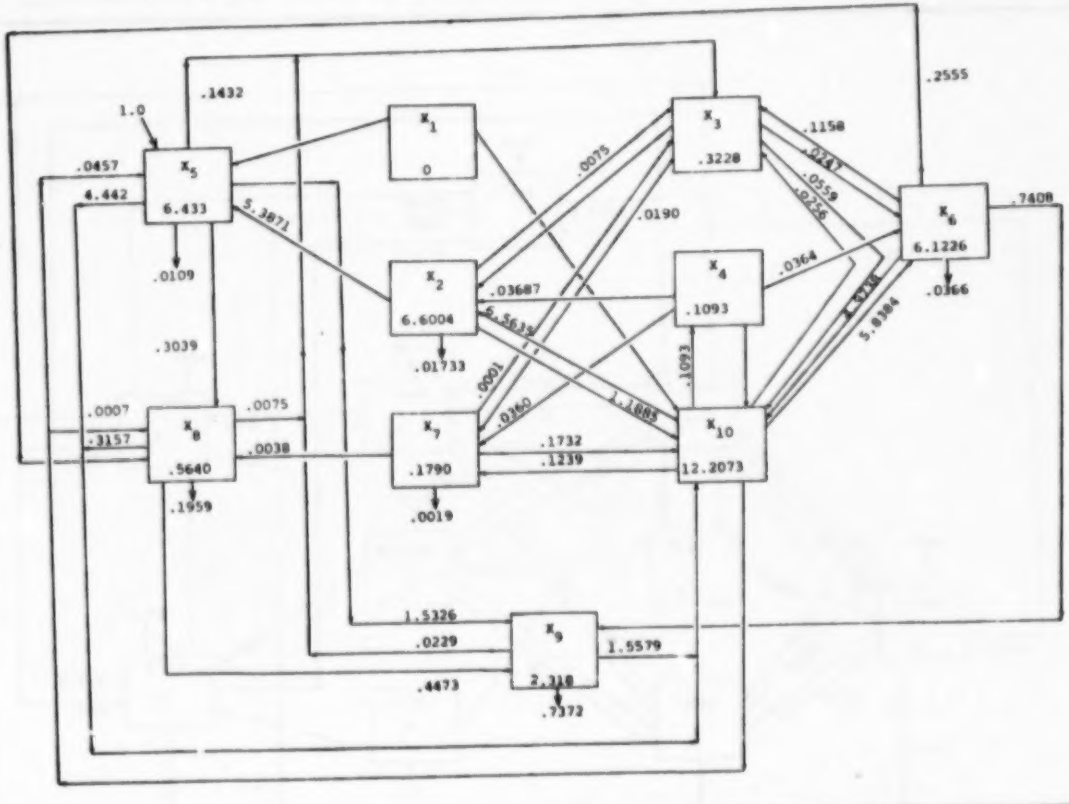
.1431
.0458
4.4423
.0109
5.3871
.3039
x_2
6.6004
.0173
.0369
.0075
.0190
x_3
.3227
.2477
.1157
.0559
.0559
.2555
x_4
.1093
.03644
x_6
6.1226
.03667
.7408
5.8384
.1093
6.5635
1.18852
.0001
.0306
x_7
.1790
.0019
.1731
.1239
x_{10}
12.7073
x_8
.5640
.1959
.0007
.3157
.0075
.0038
x_9
2.318
.7372
1.5326
.0229
.04472
1.5579

Fig. 4. Flow analysis for input of 1.0 kg wet weight to Compartment X_1. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.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4.442
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x1
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x2
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.03687
6.5639
.0001
x3
.3228
.0075
.0190
.1158
.0247
.0559
.0256
x4
.1093
.0364
.1093
x6
6.1226
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.2555
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x7
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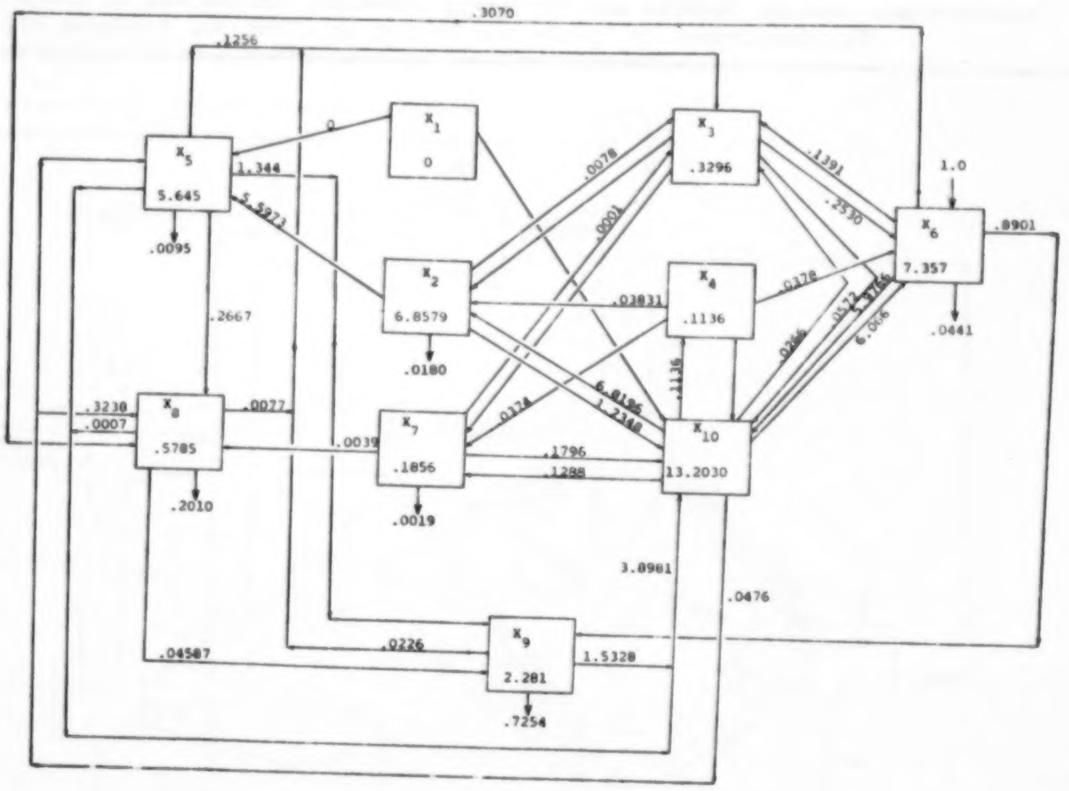
.0019
.0360
.1732
.1239
x8
.5640
.1959
.0007
.3157
.0075
.0038
x9
2.318
.7372
1.5326
.0229
.4473
1.5579
x10
12.2073
1.1085

Fig. 5. Flow analysis for input of 1.0 kg wet weight to Compartment X_5. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.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x1
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x3
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.2530
1.0
x6
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.8901
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x5
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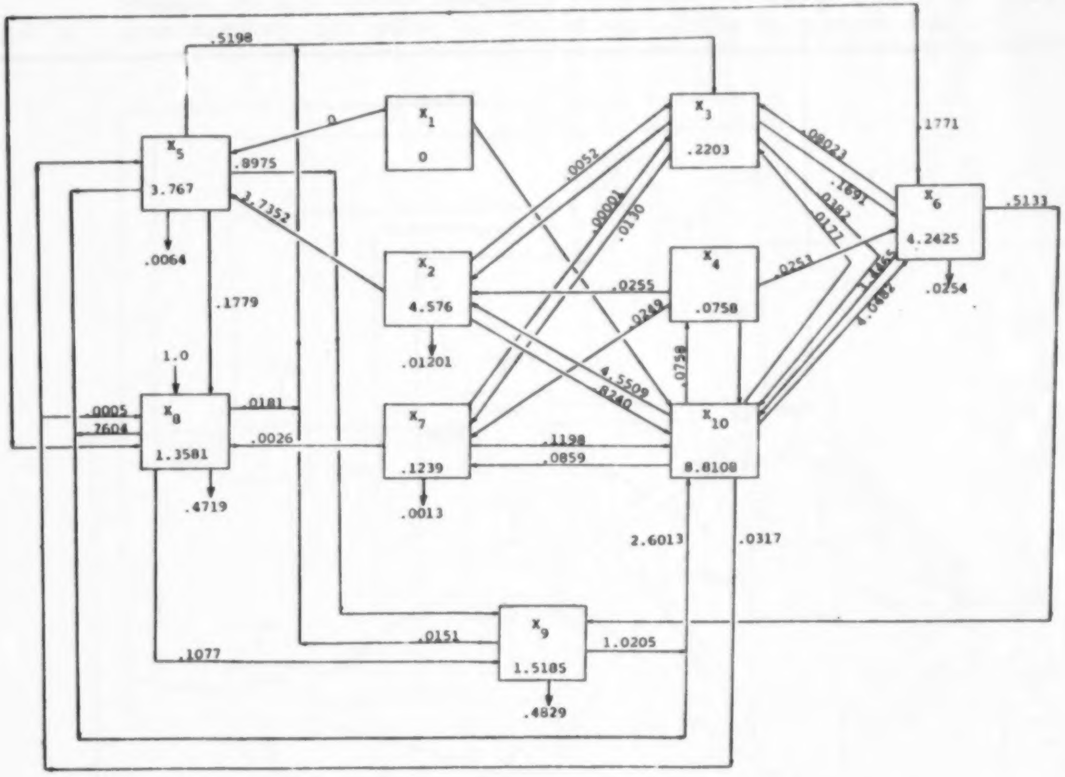
1.344
5.5973
.0095
.0078
.0001
x2
6.8579
.0180
.03831
x4
.1136
.0178
.0572
.3765
6.066
.0266
.2667
.1136
6.8196
1.2340
.0374
x8
.5785
.3230
.0007
.0077
.2010
.0039
x7
.1856
.0019
.1796
.1288
x10
13.2030
3.8981
.0476
x9
2.281
.0226
.04587
1.5328
.7254

Fig. 6. Flow analysis for input of 1.0 kg wet weight to Compartment X_6.
Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.



.5198
x_5
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.0064
.8975
2.7352
.1779
0
x_1
0
x_2
4.576
.01201
x_7
.1239
.0013
1.0
x_8
1.3581
.4719
.0005
.7604
.0181
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.1077
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.00001
.0130
x_4
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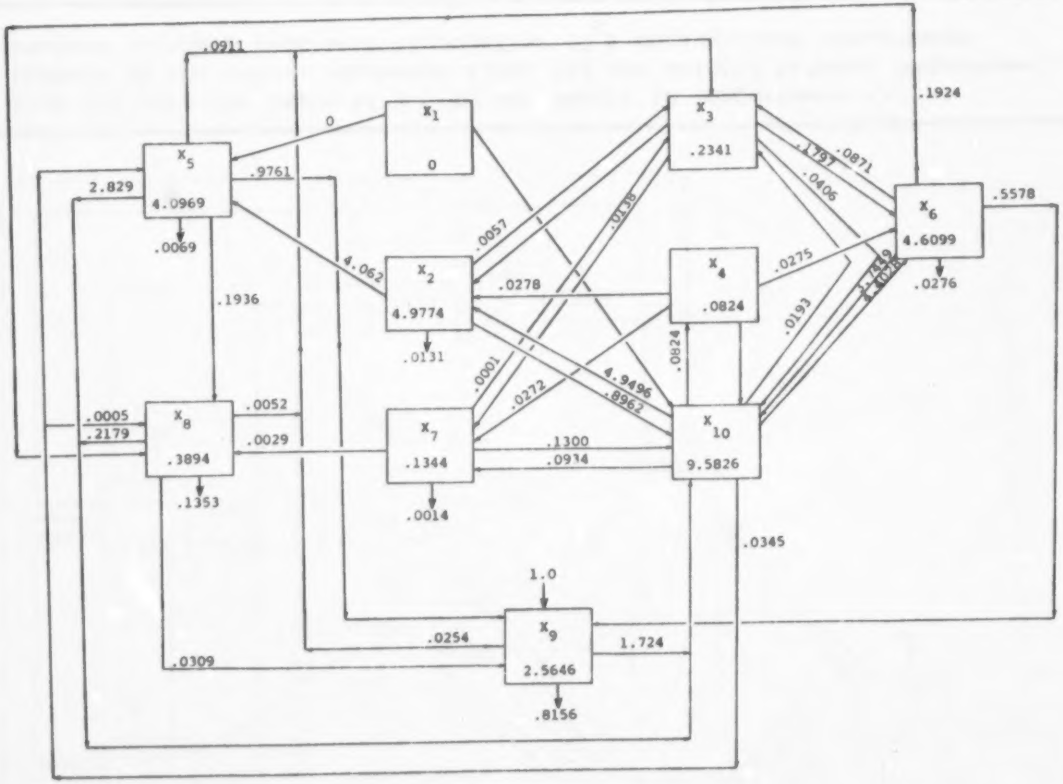
.0255
.0249
.0758
x_{10}
8.8108
4.5509
.8240
.1198
.0859
2.6013
.0317
x_6
4.2425
.0254
.1771
.5133
.08021
.1691
.0182
.0177
.0253
1.4465
4.0482
x_9
1.5185
.4829
.0151
1.0205

Fig. 7. Flow analysis for input of 1.0 kg wet weight to Compartment X_8. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.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X3
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.0406
X5
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.0069
X6
4.6099
.5578
.0276
.0057
.0138
X4
.0824
.0275
4.062
X2
4.9774
.0278
.1936
.0131
.0193
.0824
.0001
.0272
4.9496
.8962
.0005
.2179
X8
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X7
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.1300
.0934
X10
9.5826
.1353
.0014
.0345
1.0
X9
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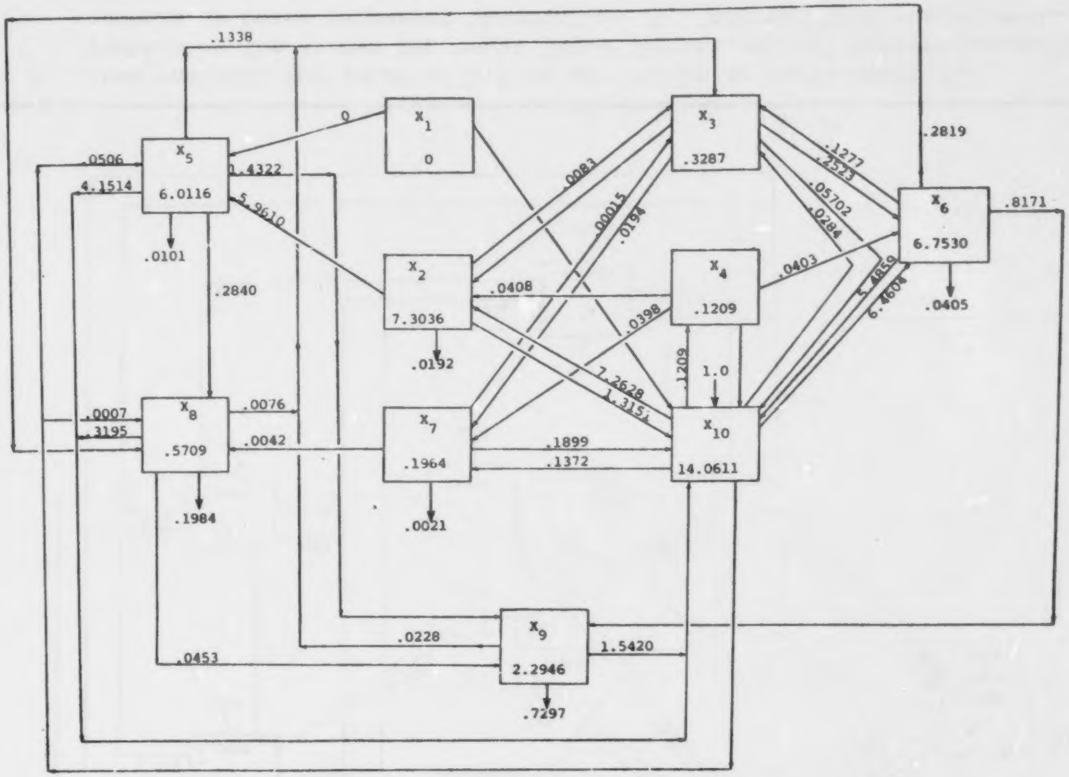
.0254
1.724
.0309
.8156

Fig. 8. Flow analysis for input of 1.0 kg wet weight to Compartment X_9. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.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x2
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x3
.3287
x4
.1209
x5
6.0116
x6
6.7530
x7
.1964
x8
.5709
x9
2.2946
x10
14.0611
.1338
0
.0506
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.4322
5.9610
.0101
.2840
.0007
.3195
.0076
.0042
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.0192
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1.0
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.1372
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.2523
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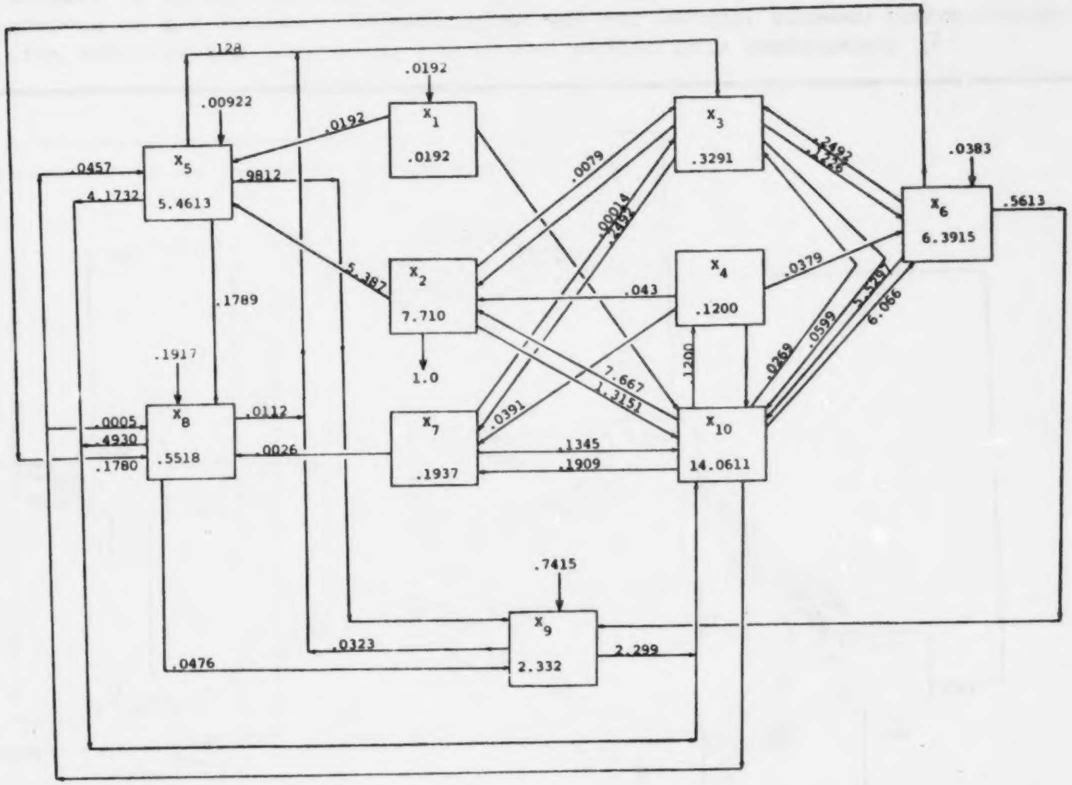
.0284
.0403
5.4859
6.4604
.2819
.8171
.0405
.0228
.0453
1.5420
.7297

Fig. 9. Flow analysis for input of 1.0 kg wet weight to Compartment X_{10}. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in toxes represent throughflow (T_k) through that compartment.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.0192
x1
.0192
x3
.3291
.2492
.1226
.0383
x6
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x5
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.9812
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.0079
.00014
.2492
x2
7.710
5.387
.043
x4
.1200
.0379
.1789
1.0
.0599
5.5297
6.066
.0269
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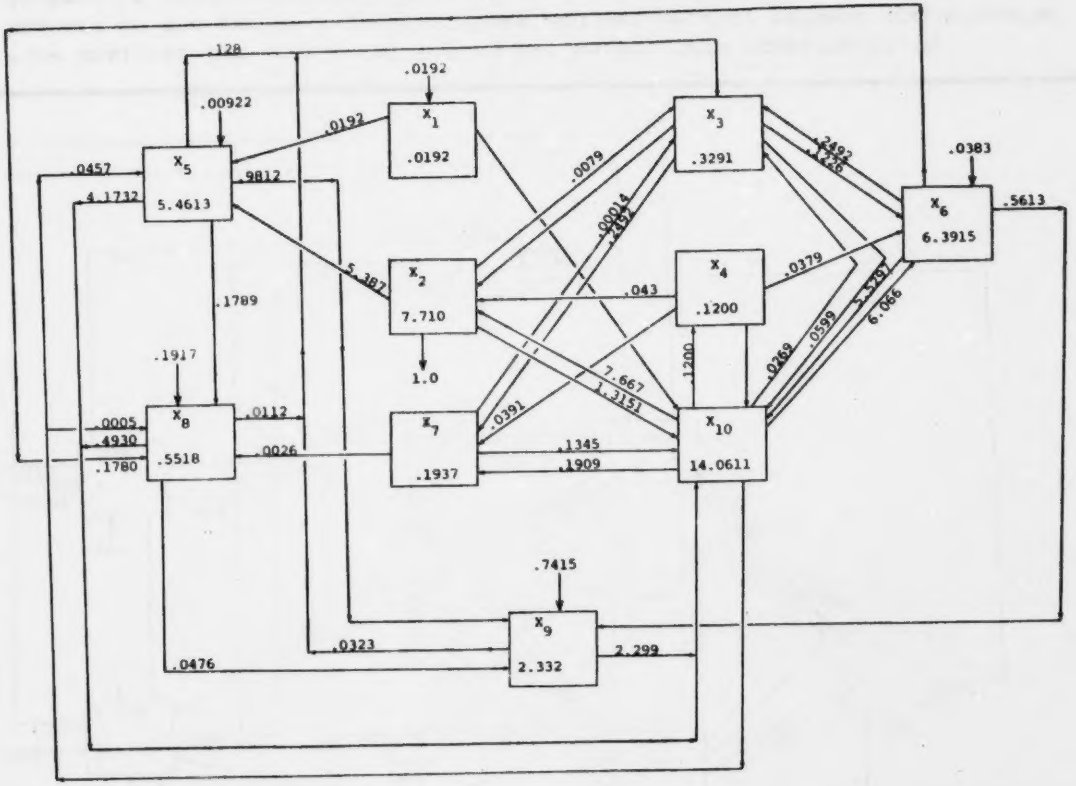
7.667
1.3151
.1917
x8
.5518
.0112
.0005
.4930
.1780
.0026
x7
.1937
.0391
.1345
.1909
x10
14.0611
.7415
x9
2.332
.0323
.0476
2.299

Fig. 10. Flow analysis for outflow of 1.0 kg wet weight from Compartment X_2. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.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X3
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.1226
X6
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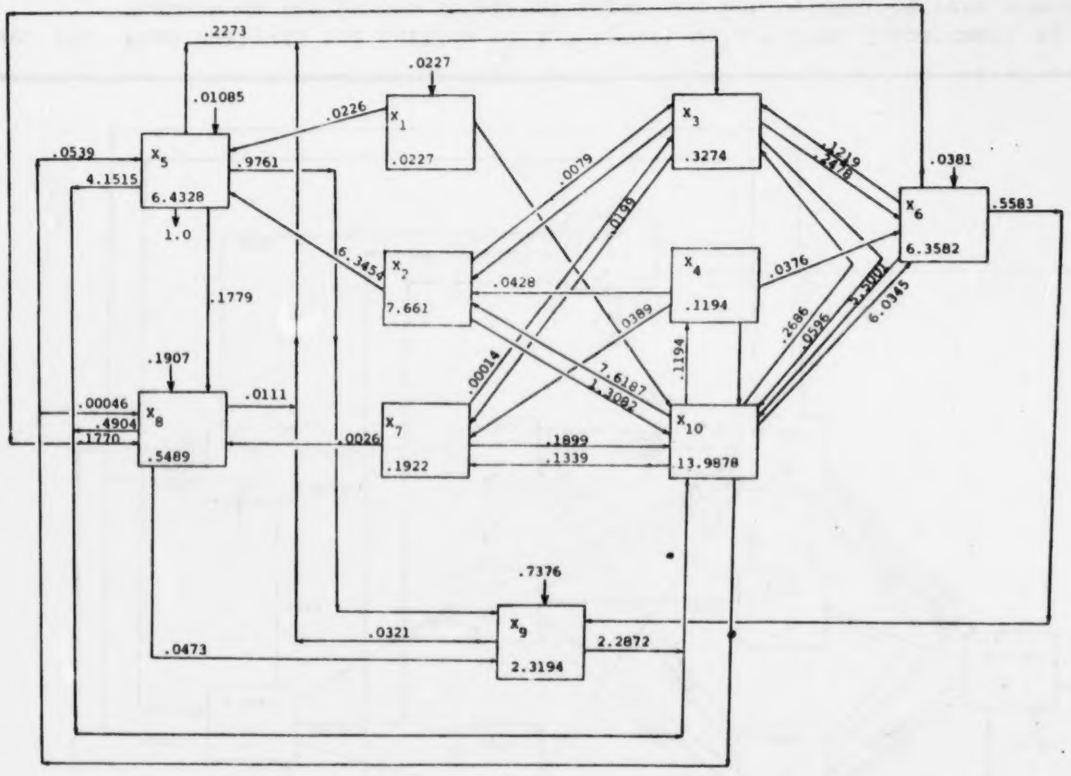
.5613
.0457
4.1732
X5
5.4613
.9812
.0079
.00014
X2
7.710
5.387
.043
X4
.1200
.0379
5.5797
6.066
.0599
.0269
.1789
1.0
.1200
.1917
X8
.5518
.0005
.4930
.1780
.0112
.0026
X7
.1937
.0391
7.667
1.3151
.1345
.1909
X10
14.0611
.7415
X9
2.332
.0323
.0476
2.299

Fig. 10. Flow analysis for outflow of 1.0 kg wet weight from Compartment X_2. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.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x_3
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x_5
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.0079
.0199
.1219
.2478
.0381
x_6
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.5583
6.3454
x_2
7.661
.0428
x_4
.1194
.0376
.2686
.0596
5.5001
6.0345
.1779
.0389
.1194
.1907
.00014
7.6187
1.3082
.00046
.4904
.1770
x_8
.5489
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x_7
.1922
.1899
.1339
x_{10}
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x_9
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.0321
.0473
2.2872

Fig. 11. Flow analysis for outflow of 1.0 kg wet weight from Compartment X_5. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.

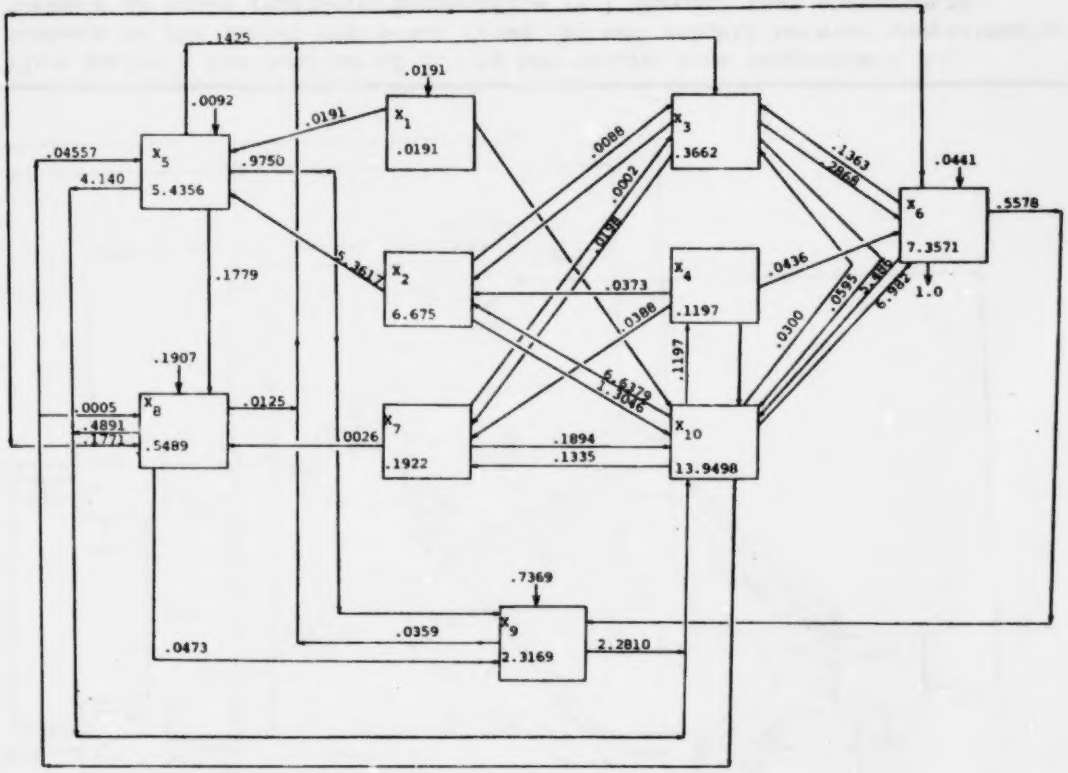
X1
.0191
.0191
X2
6.675
X3
.3662
X4
.1197
X5
5.4356
X6
7.3571
X7
.1922
X8
.5489
X9
2.3169
X10
13.9498
.0191
.0092
.1425
.04557
4.140
.9750
5.3617
.1779
.1907
.0005
.4891
.1771
.0125
.0026
.0359
.0473
.7369
2.2810
.0088
.0002
.0198
.0373
.0388
6.6379
1.3046
.1197
.1894
.1335
.0436
.0300
.0595
5.486
6.982
.1363
.2868
.0441
.5578
1.0

Fig. 12. Flow analysis for outflow of 1.0 kg wet weight from Compartment X_6. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.

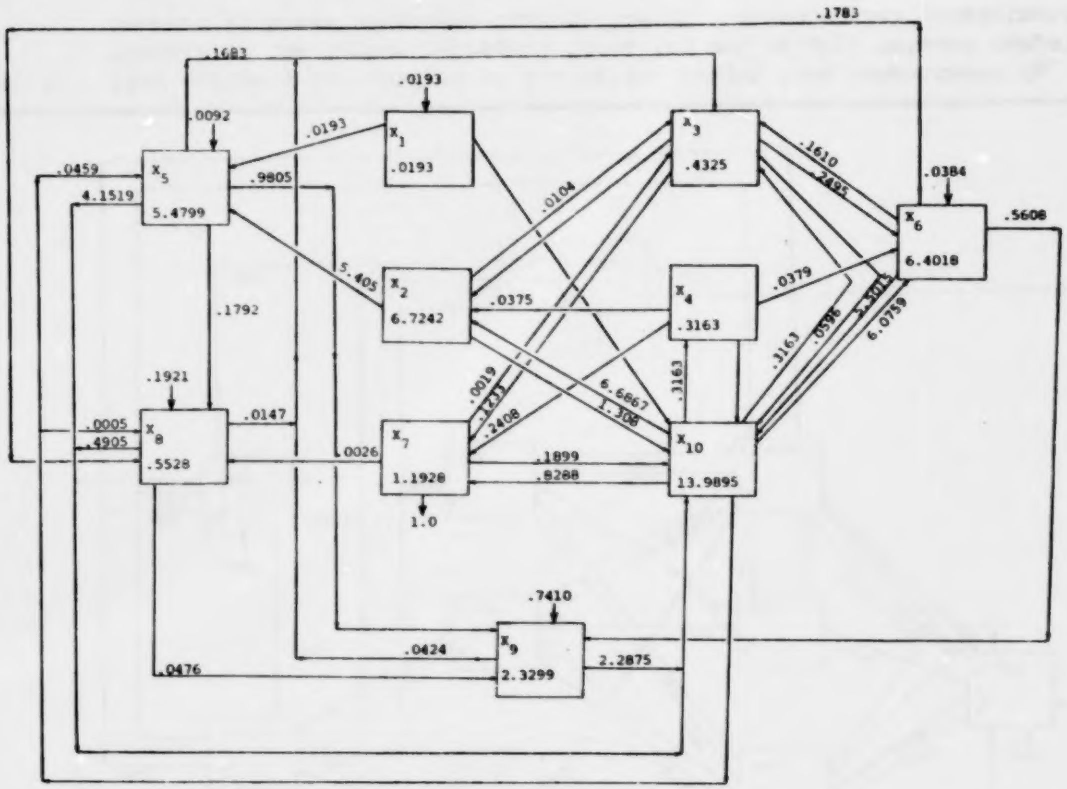
.1783
.1683
.0193
.0092
.0193
x1
.0193
x3
.4325
.1610
.2495
.0384
x6
6.4018
.5608
.0459
x5
4.1519
5.4799
.9805
.0104
5.405
x2
6.7242
.0375
x4
.3163
.0379
.1792
.3163
.0596
5.5015
6.0759
.3163
.1921
.0005
.4905
x8
.5528
.0147
.0026
x7
1.1928
.0019
.2408
6.6867
1.308
x10
13.9895
.1899
.8288
1.0
.7410
x9
2.3299
.0424
.0476
2.2875

Fig. 13. Flow analysis for outflow of 1.0 kg wet weight from Compartment X_7. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.

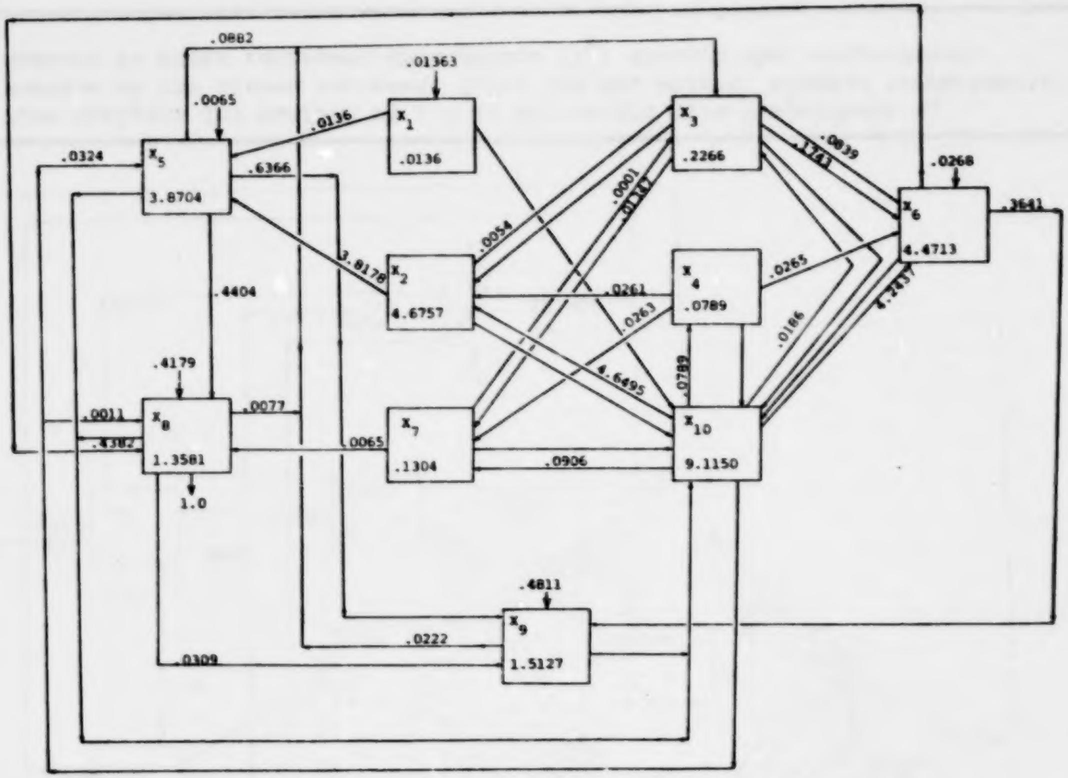
.0882
.01363
.0065
.0136
x_1
.0136
x_3
.2266
.0839
.1743
.0268
.0324
x_5
3.8704
.6366
x_6
4.4713
.3641
.0054
.0001
.0147
x_2
4.6757
3.8178
.0261
x_4
.0789
.0265
.4404
.0263
.0186
4.2437
.4179
.0789
4.6495
.0011
.4382
x_8
1.3581
.0077
.0065
x_7
.1304
.0906
x_{10}
9.1150
1.0
.4811
x_9
1.5127
.0222
.0309

Fig. 14. Flow analysis for outflow of 1.0 kg wet weight from Compartment X_8. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.

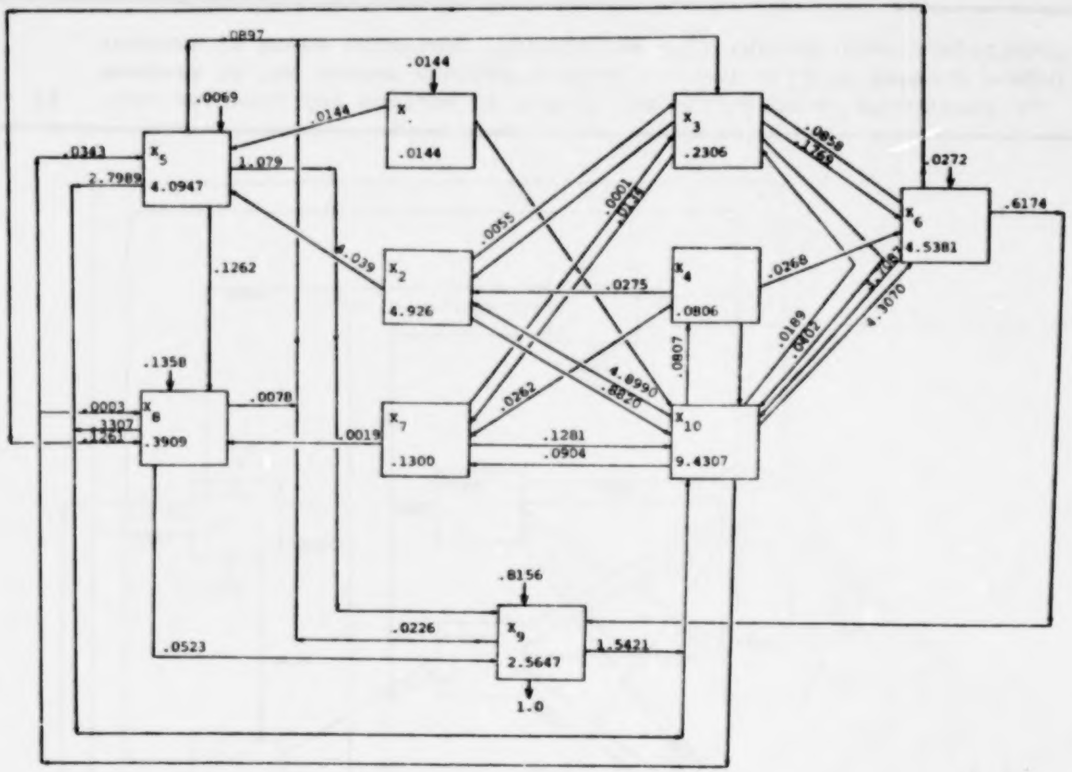
.0897
.0144
.0069
x_5
4.0947
.0343
2.7989
1.079
.0144
x
.0144
.1262
.039
x_2
4.926
.0055
.0001
x_3
.2306
.0858
.1769
.0272
x_6
4.5381
.6174
4.3070
.0268
.0275
x_4
.0806
.0189
.0402
.0807
4.0990
.8820
.0262
.1358
x_8
.3909
.0003
.3307
.1261
.0078
.0019
x_7
.1300
.1281
.0904
x_{10}
9.4307
.8156
.0226
.0523
x_9
2.5647
1.5421
1.0

Fig. 15. Flow analysis for outflow of 1.0 kg wet weight from Compartment X_9. Numbers on the arrows represent flows (kg wet weight) between compartments; numbers in boxes represent throughflow (T_k) through that compartment.

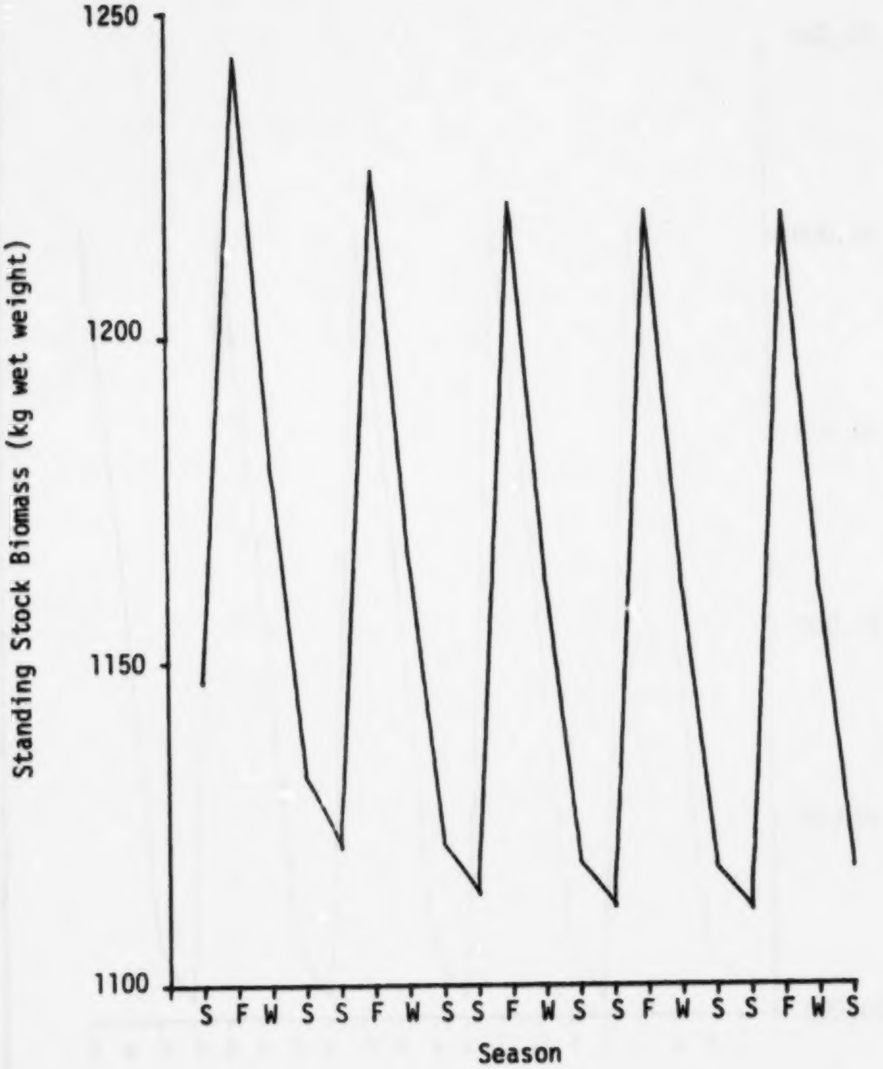

Fig. 16. Seasonal biomass dynamics for the floral fouling community (X_1).

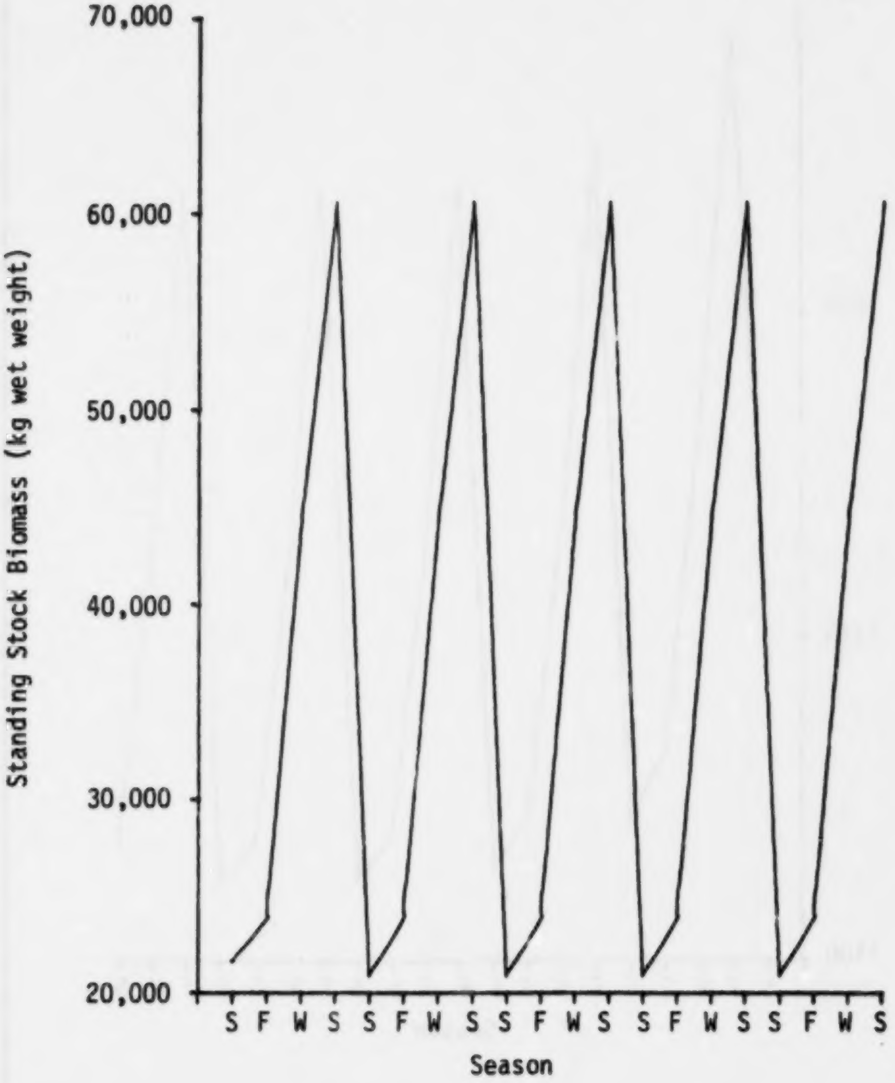

Fig. 17. Seasonal biomass dynamics for the faunal fouling community (X_2).

APPENDIX III

PROGRAM AND DOCUMENTATION

FORTRAN PROGRAM FOR SIMULATION OF THE BUCCANEER OIL FIELD ECOSYSTEM MODEL

```
/*WATFIV
C      ***  BUCCANEER FOULING COMMUNITY MODEL  ***
C    SIMULATIONS USE EULER METHOD OF NUMERICAL INTEGRATION
      EQUIVALENCE (NZ,NSEAS)
      REAL MIN,MAX
      REAL L142(5),L147(5),M512(5),M612(5),M812(5),M912(5)
      REAL L141,M312,M123,       M412,M124,L144,M125,L145,M126,L146,
     CM128,L148,M129,L149,M1012,M1210
      REAL*8 L143
      INTEGER PLOTIN,SIMT,STAR,SIM,PLINT
      INTEGER SIMT1
      DIMENSION X(14),DX(14),MRITE(14)
      DIMENSION LINE(101),XX(10,500),SEAS(5),ISEASO(500),LABEL(100)
      DIMENSION P101(5),L141(5),G213(5),M312(5),G313(5),M123(5),L143(5),
     CM412(5),G413(5),P104(5),M124(5),L144(5),G513(5),M125(5),L145(5),
     CG613(5),M126(5),L146(5),G713(5),G813(5),M128(5),L148(5),G913(5),
     CM129(5),L149(5),M1012(5),M1210(5)
      DIMENSION G113(5),T24(5),T210(5),
     CR32(5),R35(5),R36(5),R37(5),R38(5),R39(5),T310(5),T410(5),T51(5),
     CT510(5),T63(5),T64(5),T610(5),T73(5),T74(5),T710(5),T85(5),T86(5),
     CT87(5),T810(5),T95(5),T96(5),T98(5),P102(5),P103(5),P105(5),
     CP107(5),P106(5),T52(5),P108(5),P109(5),P115(5),P116(5),P118(5)
      DIMENSION P119(5)
      DATA BLANK,STAR/' ','*'/
      DATA SEAS/'W','S','S','F','5'/
      DATA P101,L141,G213,M312,G313,M123,      M412,      P104,M124,L144,
     CG513,M125,L145,G613,M126,L146,           M128,L148,      M129,L149,
     CM1012/105*0.0/
      DATA L143/5*0.0242439/
      DATA G413/5*0.012028/
      DATA G713/5*0.2276/
      DATA G813/5*0.130064/
      DATA G913/5*0.1838/
      DATA M1210/5*.0004475/
C   INPUT FLOW COEFFICIENTS
      READ (5,7) (G113(I),M512(I),M612(I),M812(I),M912(I),T24(I),
     CT210(I),
     CR32(I),R35(I),R36(I),R37(I),R38(I),R39(I),T310(I),T410(I),T51(I),T
     C52(I),T510(I),T63(I),T64(I),T610(I),T73(I),T74(I),T710(I),T85(I),T
     C86(I),T87(I),T810(I),T95(I),T96(I),T98(I),P102(I),P103(I),P105(I),
     CP106(I),P107(I),P108(I),P109(I),P115(I),
     CP116(I),P118(I),P119(I),L142(I),L147(I),I=1,4)
      READ (5,7) (G113(I),M512(I),M612(I),M812(I),M912(I),T24(I),
     CT210(I),
     CR32(I),R35(I),R36(I),R37(I),R38(I),R39(I),T310(I),T410(I),T51(I),3
     C52(I),T510(I),T63(I),T64(I),T610(I),T73(I),T74(I),T710(I),T85(I),T
     C86(I),T87(I),T810(I),T95(I),T96(I),T98(I),P102(I),P103(I),P105(I),
     CP106(I),P107(I),P108(I),P109(I),P115(I),
     CP116(I),P118(I),P119(I),L142(I),L147(I),I=5,5)
    7 FORMAT (6F12.6)
C ENTER NUMBER OF SIMULATIONS AND TYPE OF SIMULATIONS TO BE RUN
C (ITYPE WHERE 1=STEADY STATE AND 2=TIME VARIANT)
      READ (5,10) NUMSIM,ITYPE
   10 FORMAT (I3,I1)
      DO 500 SIM=1,NUMSIM
      WRITE (6,13)
   13 FORMAT (1H1//,2X,'BUCCANEER  FOULING COMMUNITY MODEL')
      IF (ITYPE.EQ.1) GO TO 600
C ENTER FIRST SEASON (NSEAS - WHERE 1=WINTER,2=SPRING,3=SUMMER,4=FALL) AND
C  ENTER LENGTH OF SIMULATION PERIOD (SIMT) IN NUMBER OF QUARTERS AND
C  ENTER PLOTTING INTERVAL (PLINT) IN NUMBER OF QUARTERS PER PLOT POINT
      READ (5,20) NSEAS,SIMT,PLINT
   20 FORMAT (I1,2I4)
      YEARS=FLOAT(SIMT)*.25
      SIMT1=SIMT+1
      WRITE (6,25) YEARS,SIMT,NSEAS
   25 FORMAT (3X,'THIS SIMULATION RUNS FOR ',F6.2,1X,' YEARS (',I4,2X,
     C'QUARTERS) AND BEGINS IN SEASON ',I2//2X,' ** INITIAL STATES **'/)
      IF (ITYPE.EQ.2) GO TO 29
C ENTER LENGTH OF SIMULATION PERIOD (SIMT) AND PLOTTING INTERVAL (PLINT)
```

```
  600 READ (5,520) SIMT,PLINT
  520 FORMAT (2I4)
      WRITE (6,525) SIMT
  525 FORMAT (3X,'THIS SIMULATION RUNS FOR ',I3,' YEARS AND BEGINS IN TH
     CE SUMMER'//2X,'** INITIAL STATE **'/)
      SIMT1=SIMT+1
C  INITIALIZE COMPARTMENT VALUES AND STORE FOR PLOTTING
   29 READ (5,30) (X(I),I=1,10)
   30 FORMAT (5F14.3)
      WRITE (6,32) (I,X(I),I=1,10)
   32 FORMAT (10(2X,'COMPARTMENT',I3,' = ',F14.3/))
      DO 35 IX=1,10
      XX(IX,1)=X(IX)
   35 CONTINUE
      IF (ITYPE.EQ.1) GO TO 40
      ISEASO(1)=NSEAS
      NSEAS=NSEAS+1
      IF (NSEAS.EQ.5) NSEAS=1
   40 IF (ITYPE.EQ.1) NSEAS=5
      WRITE (6,43)
   43 FORMAT (/2X,'  ***  ITERATIONS  **************************'/)
C  ITERATION LOOP   ***************************************************
      DO 100 ITER=2,SIMT1
C CALCULATE DERIVATIVES
       DX(1)=G113(NZ)-(T51(NZ)+P101(NZ)+L141(NZ))*X(1)
       DX(2)=T24(NZ)*X(4)+T210(NZ)*X(10)+G213(NZ)-(R32(NZ)+T52(NZ)+P102(N
     CZ)+L142(NZ))*X(2)
       DX(3)=R32(NZ)*X(2)+R35(NZ)*X(5)+R36(NZ)*X(6)+R37(NZ)*X(7)+R38(NZ)*
     CX(8)+R39(NZ)*X(9)+T310(NZ)*X(10)+M312(NZ)+G313(NZ)-(T63(NZ)+T73(NZ
     C)+P103(NZ)+M123(NZ)+L143(NZ))*X(3)
       DX(4)=T410(NZ)*X(10)+M412(NZ)+G413(NZ)-(T24(NZ)+T64(NZ)+T74(NZ)+P1
     C04(NZ)+M124(NZ)+L144(NZ))*X(4)
       DX(5)=T51(NZ)*X(1)+T52(NZ)*X(2)+T510(NZ)*X(10)+M512(NZ)+G513(NZ)-(
     CR35(NZ)+T85(NZ)+T95(NZ)+P105(NZ)+F115(NZ)+M125(NZ)+L145(NZ))*X(5)
       DX(6)=T63(NZ)*X(3)+T64(NZ)*X(4)+T610(NZ)*X(10)+M612(NZ)+G613(NZ)-(
     CR36(NZ)+T86(NZ)+T96(NZ)+P106(NZ)+F116(NZ)+M126(NZ)+L146(NZ))*X(6)
       DX(7)=T73(NZ)*X(3)+T74(NZ)*X(4)+T710(NZ)*X(10)+G713(NZ)-(R37(NZ)+T
     C87(NZ)+P107(NZ)+L147(NZ))*X(7)
       DX(8)=T85(NZ)*X(5)+T86(NZ)*X(6)+T87(NZ)*X(7)+T810(NZ)*X(10)+M812(N
     CZ)+G813(NZ)-(R38(NZ)+T98(NZ)+P108(NZ)+F118(NZ)+M128(NZ)+L148(NZ))*
     CX(8)
       DX(9)=T95(NZ)*X(5)+T96(NZ)*X(6)+T98(NZ)*X(8)+M912(NZ)+G913(NZ)-(R3
     C9(NZ)+P109(NZ)+F119(NZ)+M129(NZ)+L149(NZ))*X(9)
       DX(10)=P101(NZ)*X(1)+P102(NZ)*X(2)+P103(NZ)*X(3)+P104(NZ)*X(4)+P10
     C5(NZ)*X(5)+P106(NZ)*X(6)+P107(NZ)*X(7)+P108(NZ)*X(8)+P109(NZ)*X(9)
     C+M1012(NZ)-(T210(NZ)+T310(NZ)+T410(NZ)+T510(NZ)+T610(NZ)+T710(NZ)
     C+T810(NZ)+M1210(NZ))*X(10)
C CALCULATE COMPARTMENT VALUES
      DO 50 KC=1,10
      X(KC)=X(KC)+DX(KC)
   50 CONTINUE
      X(3)=X(3)*100
      X(4)=X(4)*10
      DO 650 MR=1,10
      MRITE(MR)=X(MR)+.5
  650 CONTINUE
      DO 651 MB=1,10
      X(MB)=MRITE(MB)
  651 CONTINUE
      X(3)=X(3)/100
      X(4)=X(4)/10
      IF (ITYPE.EQ.2) WRITE (6,55) SEAS(NSEAS),(X(I),I=1,10)
   55 FORMAT (2X,1A1,10(E12.4))
      IF (ITYPE.EQ.1) WRITE (6,555) ITER,(X(I),I=1,10)
  555 FORMAT (2X,I4,10(E12.4))
C   STORE VALUES AND SEASON FOR PLOTTING
      DO 60 IX=1,10
      XX(IX,ITER)=X(IX)
      IF (ITYPE.EQ.2) ISEASO(ITER)=NSEAS
   60 CONTINUE
```

```
C INCREMENT SEASON SUBSCRIPT IF RUNNING TIME VARYING MODEL
      IF (ITYPE.EQ.1) GO TO 100
      NSEAS=NSEAS+1
      IF (NSEAS.EQ.5) NSEAS=1
  100 CONTINUE
C  END ITERATION LOOP  **************************************************
      GO TO 500
C  PLOT SYSTEM BEHAVIOR
      READ (5,3) (LABEL(I),I=1,80)
    3 FORMAT (80A1)
      DO 99 IX=1,10
      WRITE (6,4) (LABEL(I),I=1,80)
    4 FORMAT (1H1/2X,80A1)
      WRITE (6,1) IX
    1 FORMAT (2X,'COMPARTMENT ',I3)
C SORT VALUES OF X AND CALCULATE SCALING FACTOR FOR PLOT
      IF (XX(IX,1)-XX(IX,2)) 12,12,14
   12 MIN=XX(IX,1)
      MAX=XX(IX,2)
      GO TO 112
   14 MIN=XX(IX,2)
      MAX=XX(IX,1)
  112 DO 98 ITER=3,SIMT1
      IF (XX(IX,ITER).LT.MIN) MIN=XX(IX,ITER)
      IF (XX(IX,ITER).GT.MAX) MAX=XX(IX,ITER)
   98 CONTINUE
      PLINC=(MAX-MIN)/100.0
      PLNC1=PLINC*10.0
      WRITE (6,23) MIN,MAX,PLNC1
   23 FORMAT (/2X,'ABCISSA  -  MIN=',E13.5,2X,'MAX=',E13.5,
     C2X,'PLOT INCREMENT=',E11.3)
      WRITE (6,38)
   38 FORMAT  (18X,'0',10(9X,'#'),/)
      ILINES=SIMT+1
      DO 97 ITER=1,ILINES,PLINT
      DO 220 I=1,101
      LINE(I)=BLANK
  220 CONTINUE
      IPT=((XX(IX,ITER)-MIN)/PLINC)+1.5
      LINE(IPT)=STAR
      IF (ITYPE.EQ.1) ITER11=ITER-1
      IF (ITYPE.EQ.1) WRITE (6,540) ITER11,XX(IX,ITER),(LINE(I),I=1,101)
  540 FORMAT (1X,I5,1X,E13H5,2X,101A1/)
      IF (ITYPE.EQ.1) GO TO 97
      KLM=ISEASO(ITER)
      WRITE (6,41) SEAS(KLM),XX(IX,ITER),(LINE(I),I=1,101)
   41 FORMAT (1X,1A1,1X,E13.5,2X,101A1/)
   97 CONTINUE
   99 CONTINUE
  500 CONTINUE
      STOP
      END
//$DATA
   228          149995       5999104     4500         16000            861106
  6022725      .0056343        06593          063417       005            06833
     06572       212743       90765          23390        161936        3801
  1681896       857143      484714         30626         93619       11374
     17996        17996         17897          056122       10586          60859
     6084          893132     950431         306845       408628         94545
    4295         66794          0075          03015         2666           31608
   .0130235       104377     342             149995       5999104     4500
16000           1162494      6691917         005634        131867         126835
     01           13665         13144        28366        121019          311869
    647744       506802      6727584        114286       646286        34029
   10402        126378          23994         23994         23863          074829
    10586         60859         6084           893132     950431          306845
    408628       9454545      4295           66794           0075           03015
    2666          31608        .0130235       104377     454              149995
  5999104     4500          16000            1162494     6691917         .0056343
     131867        126835       01             13665          13144         28366
   121019          31186        647744        506802     6727584        114286
  646286        34029         10402        126378          23994          23994
     23863         074829       10586          60859        6084          893132
   950431         306845        408628       9454545       4295          66794
     0075          03015        2666          31608        .0130235        104377
  228            149995        5999104     4500          16000           861106
  6022725        .0056343        06593         063417        005           06833
     06572        212743        90765          23390        161936        3801
  1681896        857143       484714        30626          93619        11374
     17996         17996          17897         056122       10586          60859
     6084          893132      950431        306845        408628         9454545
   4295          66794            0075         03015        2666           31608
   .0130235        104377
  313            149995        5999104     4500          16000           10118
  6357321        .0056343        0989          095126        0075           102489
     09858        2482          105892         272886       40484         443452
  420474         100           5655          323276        988196        1200595
     20995          20995          2088         065476       10586          60859
     6084          893132      950431        306845        408628         94545
   4295          66794            0075         03015        2666           31608
   .0130235        104377
 21
 10    1
        1147.          21653.          9.28           59.3         20000.
        19900.           297.         1688.          5062.           168.
NOMINAL STEADY STATE ** BUCCANEER MODEL  ** 10 YEARS, PLOT ECH YEAR
00250005
        1147.          21653.          9.28           59.3         20000.
        19900.           297.         1688.          5062.           168.
NOMINAL STEADY STATE BEHAVIOR * 25 YR,STRT SUM, PLOT ECH 5 YRS
/*END
```

DOCUMENTATION AND INSTRUCTIONS FOR USE OF THE SIMULATION PROGRAM

Parameterization

Values for the flow coefficients for both steady state and time-varying flow coefficients are stored in five-member one-dimensional arrays which are named after the flow they represent. The first member of the array is the winter time-varying coefficient; the fifth member is the steady state value for the coefficient. For example, flow T_{37} is stored in the array T_{37}.

T37(1) = .005 Winter values
T37(2) = .01 Spring value
T37(3) = .01 Summer value
T37(4) = .005 Fall value
T37(5) = .0075 Steady state

Integration

The Euler method of numerical integration, also known as the Rectangular method, was used to simulate the dynamics of the system behavior. For systems sharing periodic fluctuations around some mean value, the Euler method provides virtually the same precision as more complicated and expensive integration techniques (Wiegert 1977*). Solutions for X at time (t + 1) are obtained by fitting a line to X at time (t). The algorithm for the Euler method is

$$\underset{\sim}{X}_{(t+1)} = \underset{\sim}{X}_{(t)} + \Delta t(X_t)$$

$$t(\underset{\sim}{X}_t) = f(\underset{\sim}{X}_t, \underset{\sim}{P}_t, t)$$

where X are the values of the state variables and $f(\underset{\sim}{X}_t, \underset{\sim}{P}_t, t)$ represents a system of equations defining the rate of change (dX/dT) of the state variables (state transition equations).

Simulations

Both the time-varying and the steady state simulations can be performed by the program. Initial standing stocks represent biomass at the end of the summer season.

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*Wiegert, R.G. 1977. A model of a thermal spring food chain, p. 290-315. *In* Hall and Day, eds. Ecosystem modeling in theory and practice: an introduction with case histories. John Wiley & Sons, Inc.

Running the Program

A number of things are under user control in each run. For each run, the number of simulations, the plotting interval of each simulation, the type of the simulation (steady state or time-varying), and the flow coefficients can be varied. For each simulation in a run, the number, the length of the simulation, the season in which the simulation begins, the initial values of the state variables, and the plotting interval can be varied. In addition, insertion of a card, GO TO 500, after the "end iteration loop" comment card (C END ITERATION LOOP *****---), will cause the plotting procedure to be omitted. Output will include a table of the values of the state variables after every iteration, but no plots.

Data Input

The first group of data cards includes the values for time-varying flow coefficients except those which are assumed zero. Nonzero flow coefficients are entered in 6F12.6 format. Note that the coefficients are entered row by row (e.g. all winter values followed by all spring values, etc.). Steady state flow coefficients are entered next in the same order and format as the time varying coefficients.

The coefficient values are followed by a single card which determines the number of simulations to be run (NUMSIM) and the type of simulation (ITYPE). The format of the card is

Column	Variable	Format
1-4	NUMSIM	I4
5	ITYPE	A1 (where 1 = steady state 2 = time-varying)

The last group of cards in the data deck is repeated once for each simulation in the run, and the first card of the section varies depending on the value of ITYPE:

Card 1 - Steady State (ITYPE = 1)

Defines the length of the simulation period in years (SIMT) and the plot interval in years (PLINT). The format of the card is

Column	Variable	Format
1-4	SIMT	I4
5-8	PLINT	I4

Card 1 - Time-varying (ITYPE = 2)

This card indicates the first season of the simulation (NSEAS), the length of the simulation period in quarters (SIMT) and the plotting interval (PLINT). NSEAS should agree with the season used to initialize the compartment values. The format for this card is

Column	Variable	Format
1	NSEAS	I1; where 1 = summer 2 = spring 3 = fall 4 = winter
2- 5	SIMT	I4
6-10	PLINT	I4

The second and third cards of this group set the initial values of the state variables. The first contains the values for compartment one through five; the second contains the values for compartment six through ten. The format for both of these cards if 5F14.3. The final card contains the title for the plots. Everything punched on this card will be reproduced at the top of the plots. The format for the card is 80A1.

Changing Parameter Values

There are many combinations for reading in new data, changing the original data input for coefficients, or inserting specific coefficient values into the main program. It is difficult to suggest a generalized "best" way to make changes in the parameters.

1. To just change a few parameters, insert specific changes after line 21 (8 FORMAT (wX, etc.). These would be of the form:

   X(I) = Y

   where X is the coefficient name, I is the season, Y is the new value, and w is the field width of the coefficient value.

2. If a short series of values is to be changed, insert a READ statement after line 21. This would be particularly appropriate when all the seasonal values for a flow were to be varied. The form for this would be

   READ (5,7) (X(I), Y(I), ...X(I), I = 1,4)

   where X, Y, ...Z are the names of the variables to be changed. When using the read statement in this way, leave I as stated in the READ statements; it is a variable incremented from one to four in a implied do-loop. The data for this READ statement are entered on cards of format 6F12.6 which are inserted between the second and third sections of the data deck. For example, READ (5,7) (R38(I), T310(I), I = 1,4), inserted after line 21 in the program, and two data cards listing the values of R38 and T310 in this order--R38-winter, T310-winter, R38-spring, T310-spring, etc.--will change the values of R38 and T310.

3. If the READ statement above is incremented from 1 to 5 (I = 1,5), the steady state values for each flow in the read list can also be changed.

4. To change flows which have been assumed to be zero, be sure they are taken out of the DATA statement in line 14. The new values may be reinserted with another data statement, or added with any of the methods outlined above.